10% Design Report for the Hopi Arsenic Mitigation Project

IHS Project Number PH 18-V31

Indian Health Service – Phoenix Area – Eastern Arizona District

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Hopi Arsenic Mitigation Project 10% Design Package

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Hydraulic Analysis Narrative

Project: Hopi Arsenic Mitigation Regional Water System – PH 18-V31

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This project proposes to abandon the use of arsenic non-compliant wells in favor of arsenic compliant wells in the Turquoise Trail well field.

Scope

Alternative B has been chosen as the preferred alternative from an engineering standpoint. This project scope will install about 176,000 feet of pipeline to connect 1st and 2nd Mesa villages to the new regional water system. The Alternative B project will also provide 2 well pumps, 2 booster stations and 4 tanks.

Introduction

There was a proposed design in the 2014 Hopi Arsenic Mitigation Project (HAMP) Preliminary Engineering Report. This report focused on 2 alternatives, arsenic treatment and a regional water system. The arsenic treatment system was not preferred by the IHS, EPA, Tribe and Villages, but it was considered in the report and the regional water system was selected based on multiple factors as stated in the report. The route selection of the regional water system that was included in the 2014 PER was selected based on an evaluation done in the draft 2012 PER. The evaluation and scoring for 3 pipeline alignment alternatives are shown in the Environmental Assessment. The alignment named "revised" Alternative A was selected.

The pipeline in "revised" Alternative A could have been HDPE or PVC. A decision was made by Hopi Utility Corporation and IHS to design the system based on HDPE pipe. A decision was also made to not install the pipeline over the mesa top of 1st Mesa. This decision was supported by IHS, the First Mesa Consolidated Villages, and the HUC. This decision reduced the amount of head needed to provide water to 1st Mesa by about 150 ft. Another consideration was adding the cost of a powerline to the Radio Tower Tank Site and Radio Tower Booster Station shown in the 2014 PER. The PER assumed that an APS powerline would come from 2nd Mesa and pass by the Radio Tower site. The Hopi Tribe has since requested the powerline service to be provided by NTUA from the Hardrock Chapter area. That decision reduced the advantage of the Radio Tower site. The 2014 PER proposed an inline booster station to pump water to the Radio Tower Tank. An additional tank between the wells would have been considered to add some operational advantages over the inline booster system. Under the PER alternative, essentially all of the water for both 1st and 2nd mesa was being pumped to an elevation of 6300'. If the Radio Tank was moved to the Cultural Center closer to where power is at, then it would be pumping to about 6345'. Friction losses add to the pressure downstream of the booster station near the wells. The high pressure pipe for HDPE reduces the inside diameter. All the pipe to the 1st Mesa/2nd Mesa split would have needed to be 14" because of this. The pipeline to First Mesa from the split would have been a higher pressure class as well. It was determined at that point that it may be the same price or cheaper to keep the water pipe to 1st Mesa system separate from the pipe to 2nd Mesa.

The separate pipes inverted V shaped scenario was named "updated" Alternative A is one of the two alternatives compared in this analysis. First Mesa water is only needed to be pumped up to an elevation of 6203' where a tank, Hopi Tank 1, was placed at the highest point of the pipeline alignment between the wells and 1st Mesa. About 75% of this projects water is delivered to First Mesa so there is significant pumping energy savings. The operations of the system was looked at and shown to be fairly simple with the exception of the long telemetry distance between 2nd Mesa and the wells and 3 pressure reducing valves are needed. The hydraulic analysis will explain in greater detail its advantages and disadvantages.

"Updated" Alternative A was a significant increase in footage of pipe at 218,000', but much of the pipe would be smaller and a lower pressure class than needed in "revised" Alternative A. It was noticed that there would be a savings of 43,000 feet of 10" pipe to combine the 1st and 2nd Mesa water into a single transmission pipe, but in a way that is not pumping all of the water to high elevation of 2nd Mesa. This scenario is similar to Alternative B that was discussed in the Environmental Assessment report. There are some differences so this alternative so it has been renamed "updated" Alternative B, but 99% of the alignment has already been archaeologically cleared. Water is pumped to Hopi Tank 1 directly from the wells. There is no longer an additional booster station needed at the wells. Water then gravity feeds to FMCV East Tank, Hopi Tank 2 (near FMCV West Tank), and a possible BIA Keams System Tank. Water then gravity feeds from Hopi Tank 2 to Hopi Tank 3 (near Lower Sipaulovi Tank) before it is boosted to Hopi Tank 4 at the top of 2nd Mesa and again boosted to Shungopavi Tank.

Either alternative would need to boost water to the top of 2nd Mesa. "Updated" Alternative A pumps all of 2nd Mesa water to the top of 2nd Mesa and Lower Sipaulovi/Mishongnovi water would need to gravity down through 3 PRVs. Updated Alternative B would only need to pump the water for the top of 2nd Mesa.

Unfortunately, construction costs seem to be escalating at the time when funding is coming through for this project. The expected increased means that Updated Alternative A is over the current committed amount to the project by 4.5 million. Updated Alternative B is over the current committed amount by 2.2 million. Still, other weighted criteria could make Alternative A viable so a comparison was done between the 2 for pumping energy cost, life cycle cost, replacement and rehab cost, ease of operation, impact to the NEPA schedule, constructability risk, and future redundancy.

Methodology

A hydraulic analysis topographic information for the proposed Hopi Arsenic Mitigation Project (HAMP) regional water system was gathered using Trimble R8 survey equipment. Fast static basepoints were established by a professional surveyor and RTK data collection methods were utilized by IHS Hopi Office technicians. Points were then converted from the IHS modified Arizona State Plane East Ground system to the regular Arizona State Plane East Grid system using Trimble Business Center. Alignment staking had not taken place by the time of this analysis, therefore the final alignment may change from this analysis. An alignment change may change the elevation and the pipe pressure class will need to be confirmed for this new pressure by the time of the 50% Construction Document Review. The route around the west side of 1st Mesa starting from near the Upper Mesa lagoon and ending at the First Mesa East Tank has not been surveyed. Elevations were estimated from Google Earth for that section.

A design analysis sheet was created for the overall HAMP system. The design analysis sheet was updated using 2017 actual water use data from FMCV, Shungopavi, and Sipaulovi/Mishongnovi. The average water use for the 778 existing homes is about 240 GPHD. According to the Hopi Water System Strategic Plan document a pipeline has a 75 year life expectancy. Storage tanks, well pumps, and booster pumps have expected useful lives of 40, 30, and 20 years respectively. The pipeline having a 75 year useful life and the high cost for replacing the 30 plus miles of pipeline means that sizing the pipeline appropriately for future demands was critical. Therefore, a 40 year design life was chosen for the pipeline sizing. This exceeds the normal 20 year design projection typical for IHS pipeline projects. The booster station designs meet 20 year demands.

The hydraulic analysis models were used to evaluate the maximum and minimum pressures of the transmission main system. An Extended Period Simulation (EPS) scenario was also conducted over a 96-hour period to show the tank cycling, well production, and booster station flows. The NTUA demand hydrograph was used to simulate the 24 hour demand of each of the communities. The models were also used to better estimate the pumping energy used and the associated costs. Lastly, the models were used to see the Mean (Time Weighted) Water Age of parts of the water systems. Actual pump curves for the pump models shown on the schematic sheets in this package were used along with the pump efficiency curves. Motor efficiencies were found in the motor manufacturer's catalogue as well. System head curves were graphed by the software for each well pump and booster station pump.

General Design Discussion Both Alternatives

The well pumps that were selected can meet the system demands not including BIA under the year 2043 or about 25 years from now. According to the follow up well report by Shoemaker, the wells are capable of producing 415 gpm each with a predicted year 2035 drawdown of 698' for well 2 and 715' for well 3. The pump for well 2 should therefore be placed at least 720 ft below grade and for well 3 it should be placed at least 740 ft below grade to allow the easy adaptation to a bigger pump in the future. A 6-inch drop pipe will be sufficient with only 13' of headloss at a possible future pumping rate of 415 gpm.

Results

Alternative A

System head curves were developed for the selected well pumps at the 2014 static water level, at the year 1 pumping water level. Both well 2 and well 3 start out at about 282 gpm when both pumps run at the same time and the tank is full. There is a small 2 to 3 gpm increase if only one pump is running. Whether or not booster station 1 is running does not significantly affect the curve. In year 1, after the pumps run for about 300 minutes the pumping water level may drop to 5368' for well 2 and 5336' for well 3. This correlates well to the average daily pumping cycle of about 6.5 hours in year 1. The flow will reduce to 265 gpm from pump 2 and 258 gpm from pump 1 at these pumping levels. The pumping water level is predicted to decrease over time and may lead to the eventual pumping rate of around 245 gpm and 250 gpm for each well. The energy calculation shown in the Cycling and Energy Cost report are based on this pumping water levels of 5346' and 5297' BGL.

The system was modeled for year 1 using the current village data and the estimated usage of the 91 unserved homes and the Cultural Center. This year one demand was increased by 1.8% each year for the year 20 demand and the year 40 demand.

The tank cycling graph at Tank 1 showed that the tank needed to be sized to allow for operational flexibility to allow a flowrate averaging a little over 700 gpm to leave from the tank without dropping the tank level too far down while the wells fill the tank at 560 gpm at startup. 20 years from now Hopi Tank

1 would cycle 1 to 2 times per day on average if it were set to fill when it was down to 75% full. The cost of increasing the tank capacity to a more stable size is about $100,000, but it eliminates the need for flow control at FMCV East Tank. It also allows for maximizing the flow through the transmission main. Having additional storage that is under the management of Hopi Utility Corporation helps to give HUC some operational flexibility in the future.

The same 12" HDPE DIPS DR 13.5 size water line delivers water from the wells to Hopi Tank 1 in both alternatives. It provides enough capacity for future flow. From Hopi Tank 1 the water can be delivered back to the wells to supply booster station 1. Water can be fed to FMCV from Tank 1. The model utilizes a 12" IPS to deliver water to FMCV. In hindsight, this should be upgraded to a 12" DIPS to help to standardize the HDPE transition fitting needed to transition to gate valves. It is probably in the Hopi Utility Corporations interest to minimize the number of fittings that need to be stocked. There are HDPE repair couplings that adapt to all pipe outside diameters. There is the added benefit to utilizing DIPS sizes which is that these sizes allow more flow to FMCV in the future with the slight increase in inside diameter. About 650 gpm can pass through the 12" HDPE IPS pipe that was modeled.

Near FMCV, the high pressure starts to exceed 215 psi about 1 mile north of Hopi Tank 2. Generally, the waterline from this point to the East Tank has high pressure. The max pressure along this route is near FMCV's PRV #5 of the FMCV system. The maximum pressure near that location is 225 psi. The only portion of pipeline where PVC C900 pipe was considered in lieu of HDPE was at FMCV starting near FMCV's PRV #5 and ending at the point where the pipeline route turns north toward the East Tank. The initial thought was that there may need to be many tight turns, but this needs field verified. The 12" PVC CL305 C900 has a larger inside diameter which allows more water to flow through. However, strong monsoon and intense storms from Tropical storm remnants have delivered upwards of 4-inches of rain in short timeframes. Photos have been presented that show mangled FMCV PVC water and sewer lines about 8 years ago. A fused pipe system would have likely stayed in operation and not caused as big of an emergency. Consideration will be given to upgrading this segment to 14" HDPE. Possibly BIA could help with the cost to upgrade this segment from 12" HDPE to 14" HDPE. It is about 9000 ft of pipe. The would bring the total pipeline upgrade request for BIA to join this project to 27,000 ft of 12" HDPE to 14" HDPE. The projected cost of that upgrade would be about $370,000.

FMCV's West system can be fed from the FMCV East Tank system which allows the water to circulate through FMCV's East zone and keeps the East zone from becoming stagnant. The 4 parallel pressure reducing valves of FMCV can be closed.

Near wells 2 and 3, booster station 1 would pump water to Hopi Tank 2. This booster would on average supply 175 gpm to Hopi Tank 2. That would be enough capacity for 20 years including the BIA 2nd Mesa Day School. In 2037, the 12 hour average daily demand would be 162 gpm. Water is pumped through a 10-inch HDPE pipe. The pipe transitions to 8-inch near the cultural center. The highest pressure along this line is immediately downstream of booster station 1. Pressures there fluctuate between 240 psi with the pump on and 219 psi with the pump off.

At the Hopi Tank 2 site, a dedicated transmission main will feed the Hopi Booster Station 2. Also, from Hopi Tank 2, a dedicated distribution main, to be funded by a future project, could provide water to the 28 unserved Sipaulovi and Mishongnovi homes along route 17 between the Hopi Tank 4 and the Cultural Center. The booster station is designed to deliver between 100 and 112 gpm. The 40 year projected average daily flow for the Shungopavi system including a possible Cultural Center connection and the 51 unserved Shungopavi homes is 118 gpm. This size booster could deliver adequate flow over the design life. There is no potential for insufficient suction head to the booster pumps by sizing this pipe as an 8-inch even though the proposed location of the booster station is 2 miles away from Hopi Tank 4. The minimum inlet pressure to the booster station at these flows will be 24 psi. The future distribution main to the unserved Sipaulovi/Mishongnovi Route 17 homes will be able to provide adequate pressure to all of the unserved homes except one home. That home would could drop to about 11 psi and therefore would not be feasible for service. Two homes near the tank location would have a minimum pressure of about 20 psi with the tank 55' tall tank at 80% full. All pressures on the transmission line and the separate future distribution line will remain above 20 psi except for the section near Hopi Tank 4.

Booster pump 2 pumps water up to the Shungopavi Elevated storage tank. A 6-inch dedicated line keeps friction losses minimal. The single inlet/outlet pipe that ties into dual double check assembly currently in the heated box at the base of the Shungopavi Tank will need to be reconfigured as a dedicated inlet connecting the new regional water line and a dedicated outlet to the distribution system. Hopi Utility Corporation could feed the Cultural Center off of a transmission main. A branch would need to cross the road and go about 900 feet to land at the Cultural Center. The Shungopavi distribution system or the Sipaulovi distribution system could also be extended to provide water to the Cultural Center. The Cultural Center is surrounded by unserved homes that will be served by both distribution systems.

From Hopi Tank 2, a 6-inch line would transfer water to the Lower Sipaulovi Tank when the altitude valve opened. As the waterline passes through the Upper Mishongnovi and Sipaulovi community, the pipe size transitions down to 4-inch. From there, the water line begins a decent down the mesa through a series of 3 pressure reducing valves. Flow would need to be controlled to avoid drawing down Hopi Tank 2 too far. A flow of 76 gpm is all that would be needed 40 years from now including BIA.

The sum of the average daily energy delivered to each pump for alternative A is $102.23. The pump efficiency at the design flow and the motor efficiency were included in the calculation. This energy analysis was performed starting with the tanks nearly full on day one and the model was run for 96 hours. The energy cost per day would likely increase by a few dollars if the model was run for a longer period of time.

Alternative B

System head curves were developed for the well pumps at the 2014 static water level, at the year 1 pumping water level. Both well 1 and well 2 start out at 282 gpm when both pumps run at the same time when the tank is full. There is a small 2 to 3 gpm increase if only one pump is running. In year 1, after the pumps run for about 300 minutes the pumping water level may drop to 5368' for well 2 and 5336' for well 3. This correlates well to the average daily pumping cycle of about 6.5 hours in year 1. The flow will likely reduce to 263 gpm from pump 2 and 256 gpm from pump 1 at these pumping levels. The energy calculation shown in the Cycling and Energy Cost report are based on this pumping water levels of 5346' and 5297' BGL. The JSAI report predicts that the pumping water level will decrease with time. As the well pumping level decreases with time the production will decrease from these wells.

The system was modeled for year 1 using the current village data and the estimated usage of the 91 unserved homes and the Cultural Center. This year one demand was increased by 1.8% each year for the year 20 demand and the year 40 demand. A design analysis sheet was filled out for the entire HAMP system.

The tank cycling graph at Tank 1 showed that the tank needed to be sized to allow for operational flexibility to bring a flowrate averaging a little over 700 gpm through the line. 20 years from now the tank would cycle 2 times per day on average if it were set to fill when it was down to 75% full. The cost of increasing the tank capacity to a more stable size may be about $100,000, but it eliminates the need for flow control at FMCV East Tank. It also allows for maximizing the flow through the transmission main.

FMCV's West system can be fed from the FMCV East Tank system which allows the water to circulate through FMCV's East zone and keeps the East zone from becoming stagnant. The four parallel PRVs in the 1st Mesa East zone can be closed. In the future, as the East zone demand grows, then there may be future operational advantages to keeping the FMCV East and West zone separated and HAMP water can be delivered to the tank of each respective zone. One advantage could be closing off the extra altitude valve needed to go from East zone to West zone. In 40 years the average 12 hour flow demand needed to Hopi Tank 2 will be between 340-486 gpm depending on the way the FMCV West and East zones are valved off from each other. The East zone will require between 157-426 gpm. The total 12 hour average daily demand for the entire HAMP system would be 643 gpm in 40 years. When BIA's future projected use is added, the flow that can be delivered through the 12" pipe from Hopi Tank 1 is not enough to maintain a 12 hour average daily cycle. Projecting BIA's usage to 40 years gives 217 gpm to Keams and 14 gpm to 2nd Mesa Day School and leads to a total 12 hour system demand of 874 gpm. It is recommended to upsize 17,930' of 12" DR 9 transmission line between Hopi Tank 1 and Hopi Tank 2 to 14" DR 9. This pipe is located just upstream of Hopi Tank 2. The upgrade would allow 875 gpm through the transmission main. It is recommended that the BIA, the Tribal utility and the Villages try to expand the capacity of the water main beyond the 40 projection by implementing meter reading programs and charging the end user by metered volume of usage.

Near FMCV, the high pressure starts to exceed 215 psi about 1 mile north of Hopi Tank 2. Generally, the waterline from this point to the East Tank has high pressure. The max pressure along this route is near FMCV's PRV #5 of the FMCV system. The maximum pressure near that location is 225 psi. The only portion of pipeline where PVC C900 pipe was considered in lieu of HDPE was at FMCV starting near FMCV's PRV #5 and ending at the point where the pipeline route turns north toward the East Tank. The initial thought was that there may need to be many tight turns, but this needs field verified. There are HDPE bend fittings that can help. The 12" PVC CL305 C900 has a larger inside diameter which allows more water to flow through. However, strong monsoon and intense storms from Tropical storm remnants have delivered upwards of 4-inches of rain in short timeframes. Photos have been presented that show mangled FMCV PVC water and sewer lines about 8 years ago. A fused pipe system would have likely stayed in operation and not caused as big of an emergency. Consideration will be given to upgrading this segment to 14" HDPE. Possibly BIA could help with the cost to upgrade this segment from 12" HDPE to 14" HDPE. It is about 9000 ft of pipe. The would bring the total pipeline upgrade request for BIA to join this project to 27,000 ft of 12" HDPE to 14" HDPE. The projected cost of the upgrades would be about $370,000.

Hopi Tank 2 and Hopi Tank 3 cycling will be decreased by adding FMCV West Tanks and Lower Sipaulovi Tank to the model. The size of Hopi Tank 2 may be able to be decreased for the 50% drawings after further evaluation.

Flow to Hopi Tank 2 and also a possible BIA Tank must be controlled in order to maintain positive pressure before the altitude valve to FMCV East Tank. This can be done with a type of flow restriction on the line or with flow control valve incorporated into the altitude valve. Without BIA demands on the system, there is a limit of flow to Hopi Tank 2 of 850 gpm to avoid negative pressures near FMCV East Tank. If BIA were to join the project the flow setting would need to be reduced by at least the amount of flow that BIA receives plus any addition flow loss due to the additional friction losses between the Hopi Tank 2 and the tee that splits the flow to BIA and FMCV East Tank.

From Hopi Tank 2, water can be released toward Lower Sipaulovi where Hopi Tank 3 is proposed to be located next to the existing Lower Sipaulovi Tank. There would be an altitude valve on Hopi Tank 3. This would be a dedicated transmission main. The pipe size is a 10" until it passes the hospital and then transitions to 8". This sizing allows for a little over 300 gpm to flow on average without any restrictions. 40 years from now the entire 2^{nd} Mesa demand is predicted to be 229 gpm including 14 gpm for BIE's 2^{nd} Mesa Day School. Hopi Tank 3 will feed the existing Lower Sipaulovi Tank next to it as well as Hopi Booster Station 1.

Hopi Booster Station 1 pump design would provide between 145 and 155 gpm. The 40 year predicted average daily water demand from the booster station is 153 gpm. The booster station sends water to Hopi Tank 4 through an 8" pipe. The 8-inch pipe keeps friction losses to near zero and that helps to keep the pressure at the outlet of the booster station as low as possible. The highest pressure of 287 psi is under a small wash drainage just to the west of the booster station. The pressure remains above 220 psi until a little bit past the Toreva Lagoon. Ductile iron should be compared to HDPE DR 7 for approximately 3500 ft of the high pressure segment. The cost comparison between the 2 pipe materials may turn out to be fairly similar or at least not unreasonably expensive for ductile iron. Hopi Tank 4 provides the storage for the Villages of Upper Mishongnovi and Upper Sipaulovi. Hopi Utility Corporation meters along with backflow devices will need to be installed on the upper mesa to keep the Hopi Utility Corporation waterline a separate water system. Sipaulovi Utility will continue to operate and maintain the system from the meters. The existing tank, booster pump, and pressure tank could be abandoned since minimum dynamic pressures on the upper regions of the villages do not drop to less than 35 psi. The homes on the upper mesa at the lowest elevations may see pressures increase up to 95 psi. The best solution would be to place one mainline pressure reducing valve (PRV) before or after the HUC meter to reduce the pressure for approximately 30 home connections to less than 70 psi per the Navajo IHS design criteria. The pipeline size on the distribution size should be field verified to ensure that it is all at least 4-inch pipe. This PRV is not shown on the water system map, but this distribution system upgrade should be incorporated into the HAMP project.

At the Hopi Tank 4 site, a dedicated transmission main will feed the Hopi Booster Station 2. Also, from Hopi Tank 4, a dedicated distribution main, to be funded by a future project, could provide water to the 28 unserved Sipaulovi and Mishongnovi homes along route 17 between the Hopi Tank 4 and the Cultural Center. The booster station is designed to deliver between 100 and 112 gpm. The 40 year projected average daily flow for the Shungopavi system including a possible Cultural Center connection and the 51 unserved Shungopavi homes is 118 gpm. This size booster could deliver adequate flow over the design life. There is no potential for insufficient suction head to the booster pumps by sizing this pipe as an 8-inch even though the proposed location of the booster station is 2 miles away from Hopi Tank 4. The minimum inlet pressure to the booster station at these flows will be 24 psi. The future distribution main to the unserved Sipaulovi/Mishongnovi Route 17 homes will be able to provide adequate pressure to all of the unserved homes except one home. That home would could drop to about 11 psi and therefore would not be feasible for service. Two homes near the tank location would have a minimum pressure of about 20 psi with the tank 55' tall tank at 80% full. All pressures on the transmission line and the separate future distribution line will remain above 20 psi except for the first section near Hopi Tank 4.

Booster 2 pumps water up to the Shungopavi Elevated storage tank. A 6-inch dedicated line keeps friction losses minimal. The single inlet/outlet pipe that ties into dual double check assembly currently in the heated box at the base of the Shungopavi Tank will need to be reconfigured as a dedicated inlet connecting the new regional water line and a dedicated outlet to the distribution system. The Shungopavi distribution system or the Sipaulovi distribution system could be extended to provide water to the Cultural Center. The Cultural Center is surrounded by unserved homes that will be served by both distribution systems.

Alternative B allows for redundant tanks operated by different operators at 2 tank locations. Having the additional tank at each location helps to keep the Hopi Utility Corporation system separate from the village utility system. It also allows for greater operational flexibility if a tank needs to be taken offline for repair or maintenance.

The sum of the average daily energy delivered to each pump for alternative A is $98.80. The pump efficiency at the design flow and the motor efficiency were included in the calculation. This energy analysis was performed starting with the tanks nearly full on day one and the model was run for 96 hours. The energy cost per day would likely increase by a few dollars if the model was run for a longer period of time.

Conclusion

Both of these alternative work well from a hydraulic standpoint and would be good options for the HAMP. Both of these alternatives utilize about the same amount of pumping energy. Pressure reducing valves tend to periodically fail. A failure of this type can permanently damage the downstream pipe by over pressurizing it. Fail safe mechanisms could be put in place, but they add complexity. Alternative B does not contain any pressure reducing valves. Alternative B only contains one pressure reducing valve for the Upper 2nd Mesa distribution system, but does contain one more altitude valve than Alternative A. If an altitude valve was not set up correctly, it could possibly overflow the tank. The pressure reducing valves therefore are a far greater risk to the long term sustainability of the system.

Alternative B may be considered to have greater redundancy and flexibility because of the additional tank at 2 existing tank sites.

Other Assumptions and Constraints

1. This waterline is for the regional water transmission system. As such, it needs to remain a separate system from the village systems.
2. Since this is a regional transmission main, a peak factor was not used in the minimum dynamic pressure analysis. Pipeline sizing is for the year 2047 is based on a 12 hour average daily

pumping cycle per the Navajo IHS Criteria and the actual pump flow that will be able to deliver that demand. The 12 hour average daily pumping cycle allows for some extra pumping time on days within peak usage months.

3. Cultural Center water usage was estimated and included in the design.
4. A future Kykotsmovi connection was not considered in the design.
5. Annual growth rate of 1.8% was utilized for the entire population. This is a modest growth projection compared to the 2000-2010 Census Data that showed 2.61% population growth. Supporting the 1.8% annual growth rate is the 2013-2017 village utility water usage data that shows about a 2% increase year over year.
6. The largest utility FMCV uses 75% of the water not including BIA
7. Tank maximum water level height of 6203' is needed to achieve a 30 year flow requirement to FMCV East Tank includes BIA usage. Metered rate at FMCV may reduce future usage. Possibly could get additional flow by adding a booster station 30 years in the future. Going higher for a tanksite in the future may be another option. If air were to infiltrate the line, flow capacity of the 12" pipe may be reduced.
8. Actual pipe diameters were used.
9. A Hazen-Williams coefficient of 140 was used for PVC pipe, 120 psi was used for galvanized iron, and 110 was used for ductile iron pipe.
10. PRV locations need to be field verified. If they are moved from the locations of this model, then the settings may need to be adjusted to the new elevation.
11. Pending is the approval of the viewshed of Hopi Tank #3. The tank height will need to be 56 feet to meet the pressure needs at the houses. 50 feet tank height would be ok, but it is on the edge of not being able to serve a few homes. A preliminary viewshed model has been generated using a Google Earth projected. The results will be presented to the Village of Shungopavi for approval, but maybe it would be possible to project an image of the tank at the location in the field to give them a better idea.
12. A backup emergency water source to the Route 17 Hopi Tank from Shungopavi Tank could be discussed and a future normally closed valve from the Shungopavi distribution system could be installed on the booster station 2 bypass line.
13. Minimize pump energy usage as much as possible.
14. Simplicity of controls was considered an advantage in the layouts and designs.
15. Fireflow analysis was not conducted as part of this analysis. However it is a given, than if the Cultural Center be served of off the transmission main, fire flow would not be available off of HUC Tank #3 because the water pressure at some homes would fall below 20 psi. An undetermined amount of fire flow may be made available by the Shungopavi tank distribution line, if the Cultural Center and Shungopavi were to agree to that.
16. Pipe table, see appendix, lists inside diameter, maximum pressure allowed, and the temperature derated maximum pressure specified by the engineer.
17. Power need for the Turquoise Trail Wells will be provided through an NTUA powerline extension. APS to provide power needed for the Hopi Tribe's 2nd Mesa Booster Station.
18. Solar electrical will be needed at Hopi Tank #1 and may be needed at the Hopi Tank at Route 17.
19. Location of a future well is not known. Sizing of pipe from wells to tank is uncertain.

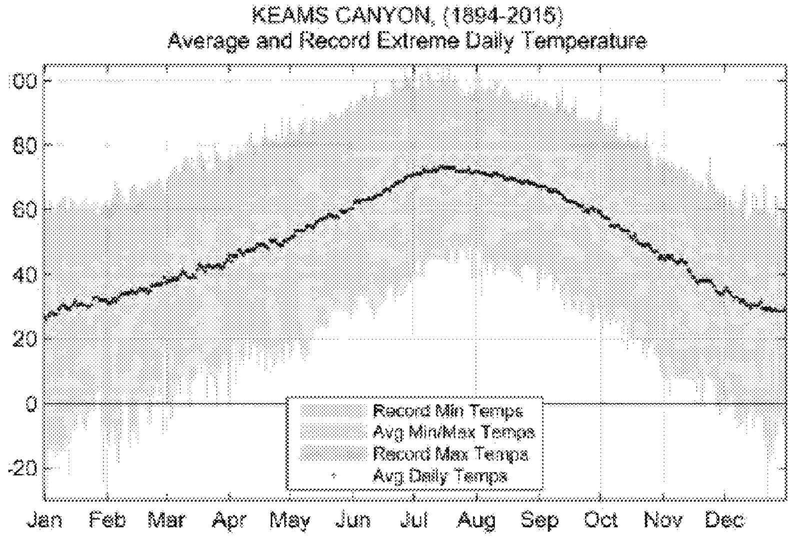
Temperature Considerations in Design

The water temperature affects the working pressure of HDPE pipe. HDPE pipe manufacture data shows operating temperature multipliers that decrease the working pressure rating. See table below courtesy of WL Plastics.

Table 3 PE4710 Operating Temperature Multiplier, f_T, for operating Temperature in °F

°F	f_T	°F	f_T	°F	f_T	°F	f_T	°F	f_T
32	1.28	54	1.12	76	0.98	98	0.85	120	0.73
33	1.27	55	1.12	77	0.97	99	0.84	121	0.72
34	1.27	56	1.11	78	0.97	100	0.84	122	0.72
35	1.26	57	1.10	79	0.96	101	0.83	123	0.71
36	1.25	58	1.10	80	0.96	102	0.83	124	0.71
37	1.24	59	1.09	81	0.95	103	0.82	125	0.70
38	1.24	60	1.08	82	0.94	104	0.82	126	0.70
39	1.23	61	1.08	83	0.94	105	0.81	127	0.69
40	1.22	62	1.07	84	0.93	106	0.80	128	0.69
41	1.21	63	1.06	85	0.93	107	0.80	129	0.68
42	1.21	64	1.06	86	0.92	108	0.79	130	0.68
43	1.20	65	1.05	87	0.91	109	0.79	131	0.67
44	1.19	66	1.04	88	0.91	110	0.78	132	0.67
45	1.19	67	1.04	89	0.90	111	0.78	133	0.66
46	1.18	68	1.03	90	0.90	112	0.77	134	0.66
47	1.17	69	1.03	91	0.89	113	0.77	135	0.65
48	1.17	70	1.02	92	0.88	114	0.76	136	0.65
49	1.16	71	1.01	93	0.88	115	0.75	137	0.64
50	1.15	72	1.01	94	0.87	116	0.75	138	0.63
51	1.14	73	1.00	95	0.87	117	0.74	139	0.63
52	1.14	74	0.99	96	0.86	118	0.74	140	0.63
53	1.13	75	0.99	97	0.86	119	0.73		

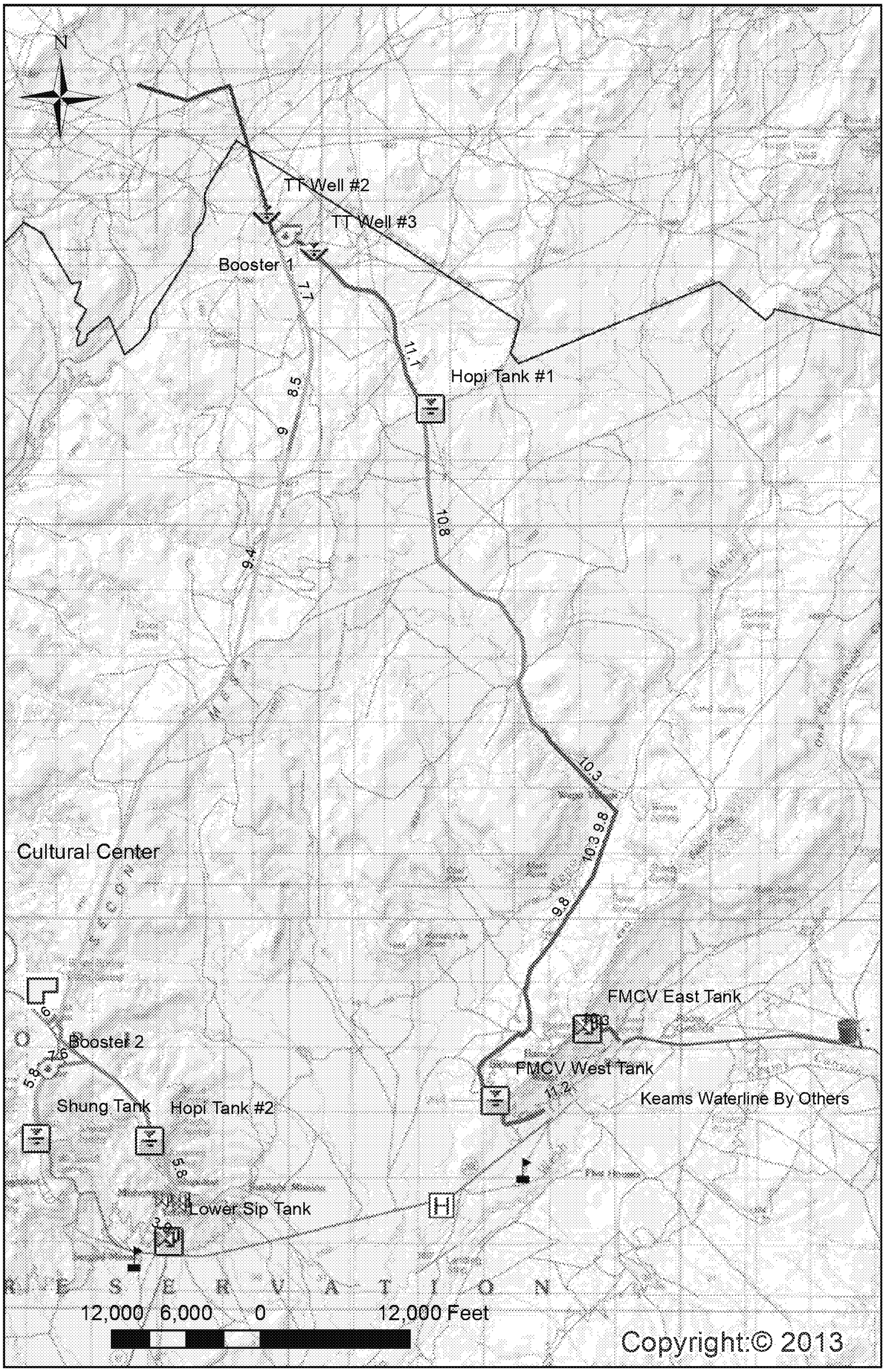
The Hopi maximum average high temperature is about 88 degrees F. The water comes out of deep wells and may sit go in days at the most, and then will be piped through HDPE underground to the tanks that feed the existing PVC pipe distribution system. Each day new well water is added to the tank. An estimated maximum water temperature of 90 degrees at the Turquoise Trail tank was used to find the operating temperature multiplier. The operating temperature multiplier used was 0.90. This multiplier is also consistent with AWWA Manual M55 Chapter 4 1st edition.



From the operating temperature multiplier for the project area, the maximum operational pressures for the project were derived. Below is the table for the piping proposed on this project.

PIPE DIMENSION DATA								
Nom Size	**Material**	**Pressure Rating**	**Type**	**O.D. (Inches)**	**I.D. (Inches)**	**SDR**	**ASTM**	**MAX. OPERATIONAL PRESSURE**
4"	HDPE 4710	250 PSI	IPS	4.500	3.440	9	AWWA-C906	225 PSI
4"	HDPE 4710	250 PSI	DIPS	4.800	3.670	9	AWWA-C906	225 PSI
4"	HDPE 4710	200 PSI	IPS	4.500	3.633	11	AWWA-C906	180 PSI
4"	HDPE 4710	200 PSI	DIPS	4.800	3.876	11	AWWA-C906	180 PSI
4"	HDPE 4710	160 PSI	IPS	4.500	3.794	13.5	AWWA-C906	145 PSI
4"	HDPE 4710	160 PSI	DIPS	4.800	4.045	13.5	AWWA-C906	145 PSI
6"	HDPE 4710	250 PSI	IPS	6.625	5.060	9	AWWA-C906	225 PSI
6"	HDPE 4710	250 PSI	DIPS	6.900	5.274	9	AWWA-C906	225 PSI
6"	HDPE 4710	200 PSI	IPS	6.625	5.350	11	AWWA-C906	180 PSI
6"	HDPE 4710	200 PSI	DIPS	6.900	5.571	11	AWWA-C906	180 PSI
6"	HDPE 4710	160 PSI	IPS	6.625	5.584	13.5	AWWA-C906	145 PSI
6"	HDPE 4710	160 PSI	DIPS	6.900	5.817	13.5	AWWA-C906	145 PSI
8"	HDPE 4710	333 PSI	IPS	8.625	6.010	7	AWWA-C906	300 PSI
8"	HDPE 4710	333 PSI	DIPS	9.050	6.309	7	AWWA-C906	300 PSI
8"	HDPE 4710	250 PSI	IPS	8.625	6.590	9	AWWA-C906	225 PSI
8"	HDPE 4710	250 PSI	DIPS	9.050	6.917	9	AWWA-C906	225 PSI
8"	HDPE 4710	200 PSI	IPS	8.625	6.960	11	AWWA-C906	180 PSI
8"	HDPE 4710	200 PSI	DIPS	9.050	7.305	11	AWWA-C906	180 PSI
8"	HDPE 4710	160 PSI	IPS	8.625	7.270	13.5	AWWA-C906	145 PSI
8"	HDPE 4710	160 PSI	DIPS	9.050	7.630	13.5	AWWA-C906	145 PSI
10"	HDPE 4710	333 PSI	IPS	10.750	7.500	7	AWWA-C906	200 PSI
10"	HDPE 4710	333 PSI	DIPS	11.100	7.738	7	AWWA-C906	200 PSI
10"	HDPE 4710	250 PSI	IPS	10.750	8.219	9	AWWA-C906	225 PSI
10"	HDPE 4710	250 PSI	DIPS	11.100	8.486	9	AWWA-C906	225 PSI

Nom Size	Material	Pressure Rating	Type	O.D. (Inches)	I.D. (Inches)	SDR	ASTM	MAX. OPERATIONAL PRESSURE
10"	HDPE 4710	200 PSI	IPS	10.750	8.679	11	AWWA-C906	180 PSI
10"	HDPE 4710	200 PSI	DIPS	11.100	8.961	11	AWWA-C906	180 PSI
10"	HDPE 4710	160 PSI	IPS	10.750	9.062	13.5	AWWA-C906	145 PSI
10"	HDPE 4710	160 PSI	DIPS	11.100	9.357	13.5	AWWA-C906	145 PSI
12"	HDPE 4710	333 PSI	IPS	12.750	8.900	7	AWWA-C906	300 PSI
12"	HDPE 4710	333 PSI	DIPS	13.200	9.202	7	AWWA-C906	300 PSI
12"	HDPE 4710	250 PSI	IPS	12.750	9.750	9	AWWA-C906	225 PSI
12"	HDPE 4710	250 PSI	DIPS	13.200	10.090	9	AWWA-C906	225 PSI
12"	HDPE 4710	200 PSI	IPS	12.750	10.290	11	AWWA-C906	180 PSI
12"	HDPE 4710	200 PSI	DIPS	13.200	10.656	11	AWWA-C906	180 PSI
12"	HDPE 4710	160 PSI	IPS	12.750	10.750	13.5	AWWA-C906	145 PSI
12"	HDPE 4710	160 PSI	DIPS	13.200	11.127	13.5	AWWA-C906	145 PSI
12"	PVC CL 305	305 PSI		13.200	11.200	14	AWWA - C900	277 PSI



Legend

- Possible_BIA_Tank_Location
- Booster Pumps
- Flow Control Valve
- Pressure Reducing Valve
- Altitude Valves
- Tanks
- Wells
- Possible BIA Waterline
- NTUA Powerline to Turq Trl
- <all other values>

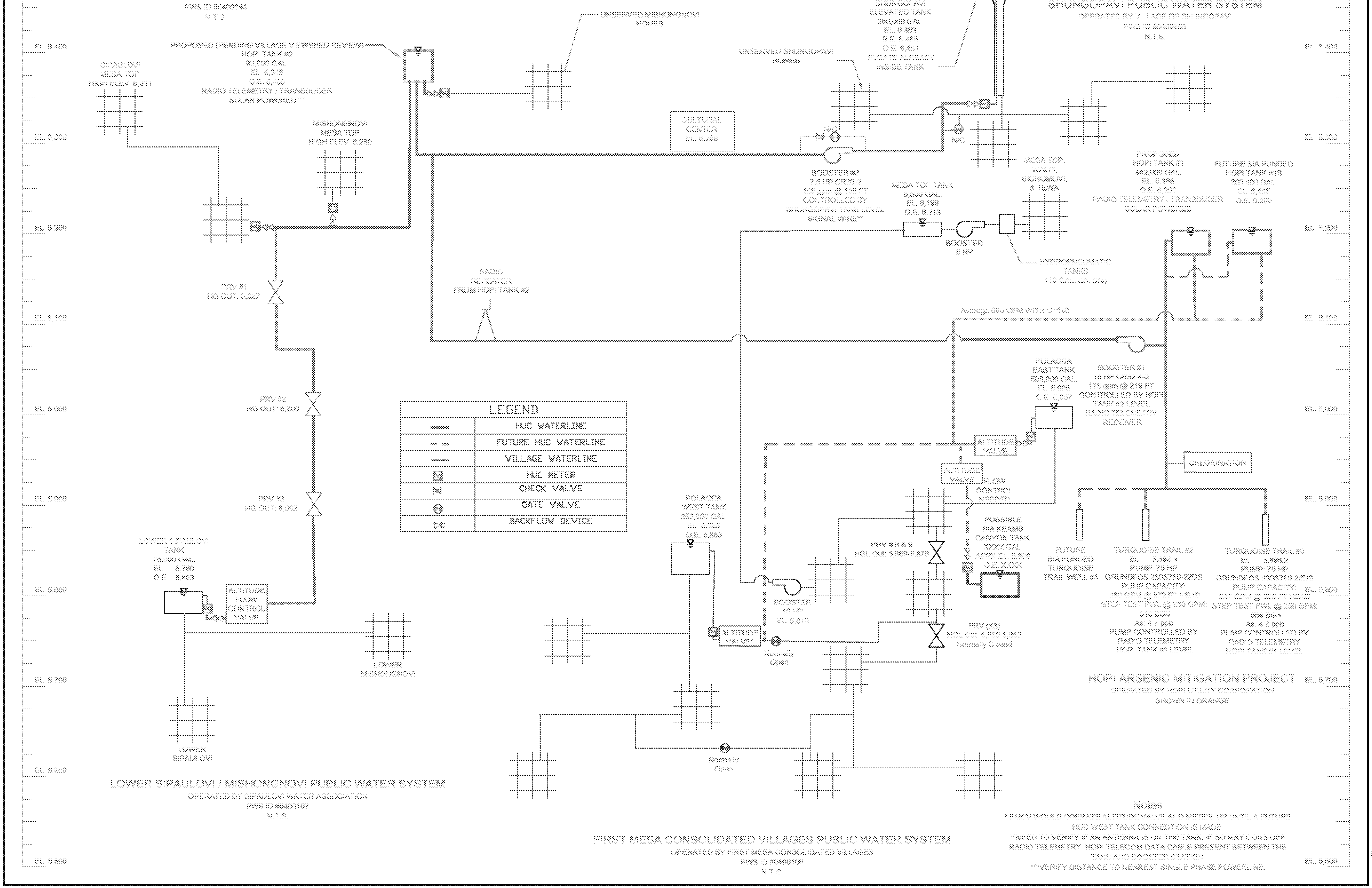
PipeName

- 10-inch HDPE DIPS DR 11
- 10-inch HDPE DIPS DR 13.5
- 10-inch HDPE DIPS DR 7
- 10-inch HDPE DIPS DR 9
- 12-inch HDPE DIPS DR 13.5
- 12-inch HDPE IPS DR 11
- 12-inch HDPE IPS DR 13.5
- 12-inch HDPE IPS DR 9
- 12-inch PVC C900 305
- 4-inch HDPE DIPS DR 11
- 6-inch HDPE DIPS DR 13.5
- 6-inch HDPE DIPS DR 9
- 8-inch HDPE DIPS DR 13.5
- BUILDING
- School
- Hospital
- District_6_83

NOTE: NUMBERS ON PIPELINE CORRESPOND TO THE INSIDE DIAMETER.

Indian Health Service Office of Environmental Health & Engineering	**Phx Area IHS-Eastern Arizona District - Polacca Office** **Hopi Arsenic Mitigation Project** **Updated Alternative A Regional Water System Map** **IHS SDS Project AZ09981-0601**	
Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	Date: 7/9/18 Drawn By: JPC/NC	pg. 13

PROPOSED RURAL WATER SYSTEM FACILITIES SCHEMATIC
UPDATED ALTERNATIVE A



Notes
* FMCV WOULD OPERATE ALTITUDE VALVE AND METER UP UNTIL A FUTURE HUC WEST TANK CONNECTION IS MADE.
**NEED TO VERIFY IF AN ANTENNA IS ON THE TANK. IF SO MAY CONSIDER RADIO TELEMETRY. HOPI TELECOM DATA CABLE PRESENT BETWEEN THE TANK AND BOOSTER STATION
***VERIFY DISTANCE TO NEAREST SINGLE PHASE POWERLINE.

DATE	REVISIONS	INIT
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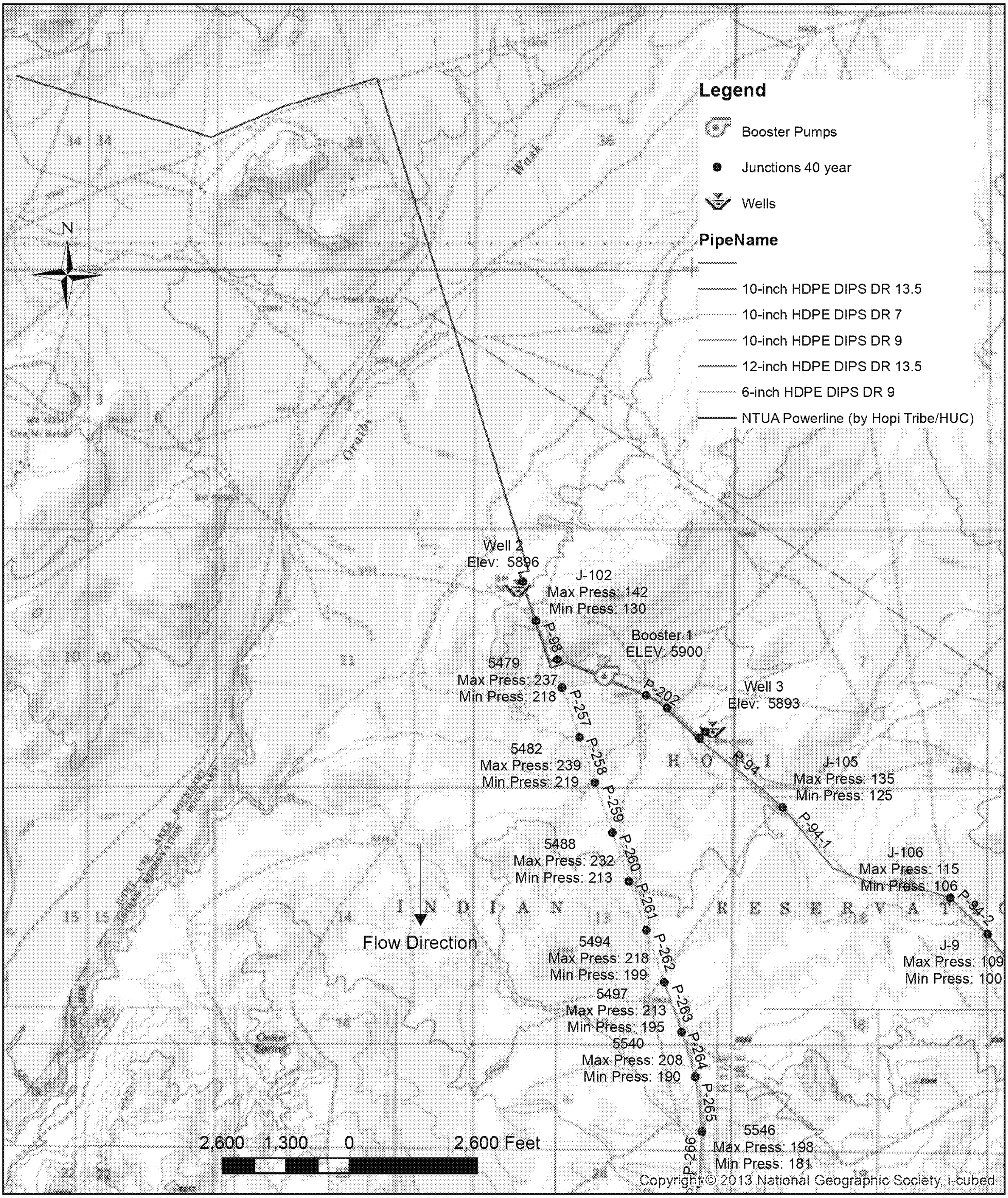
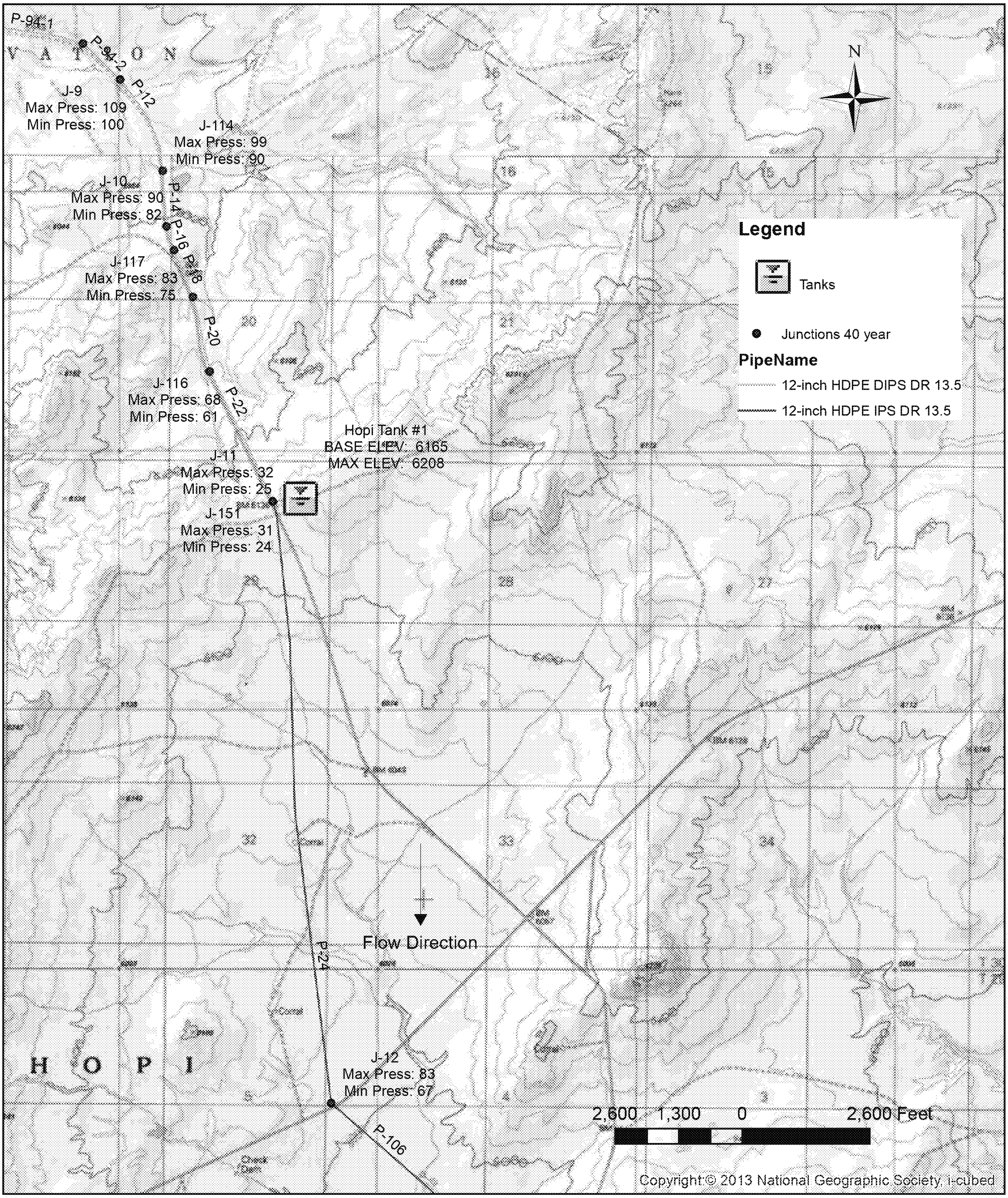
INDIAN HEALTH SERVICE 1955

THE HOPI TRIBE
HOPI RESERVATION – NAVAJO COUNTY, ARIZONA
HOPI ARSENIC MITIGATION PROJECT
EXISTING FACILITIES SCHEMATICS
PH 18-V31

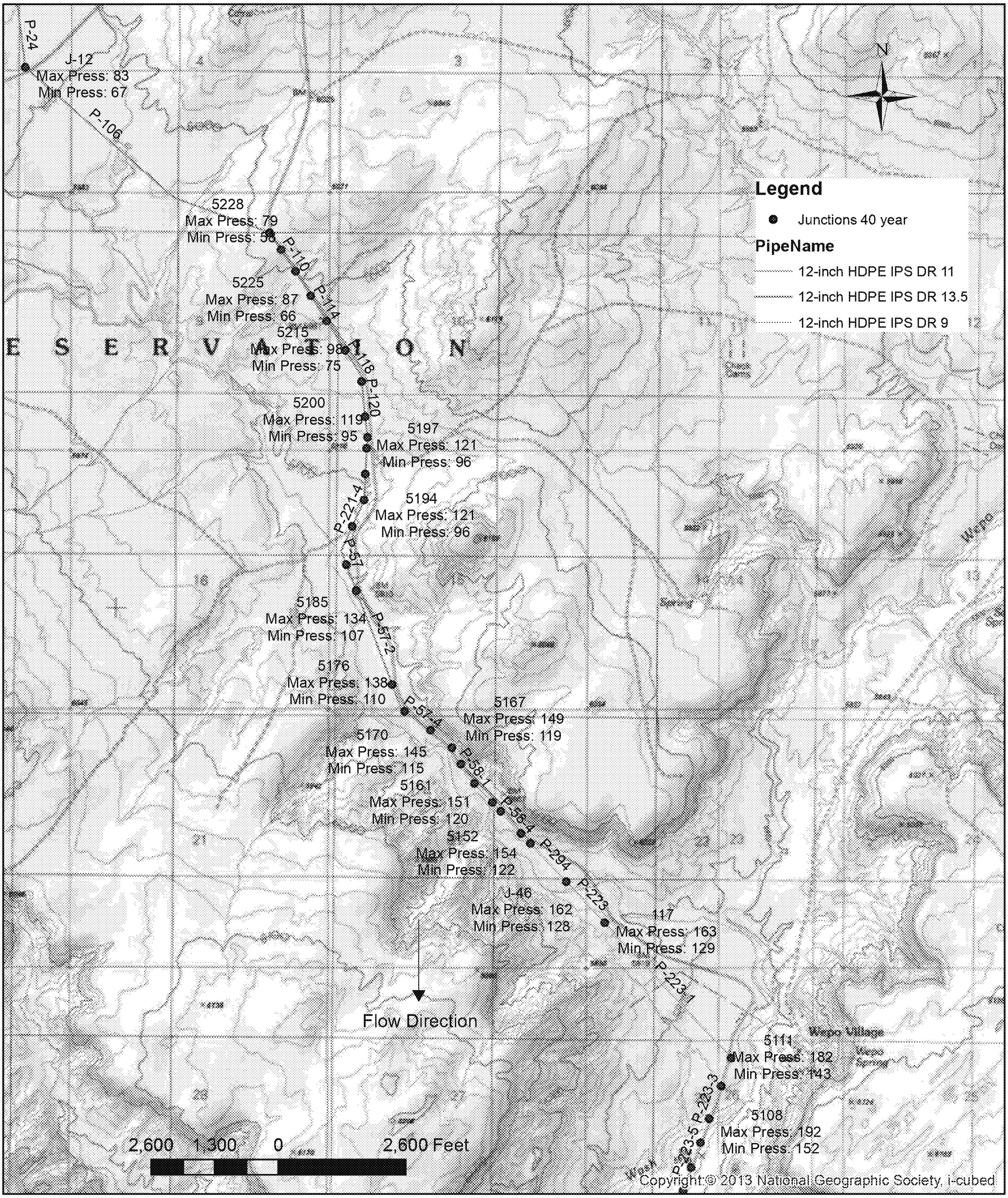
G-101 Alt A
SHEET 03 OF 24



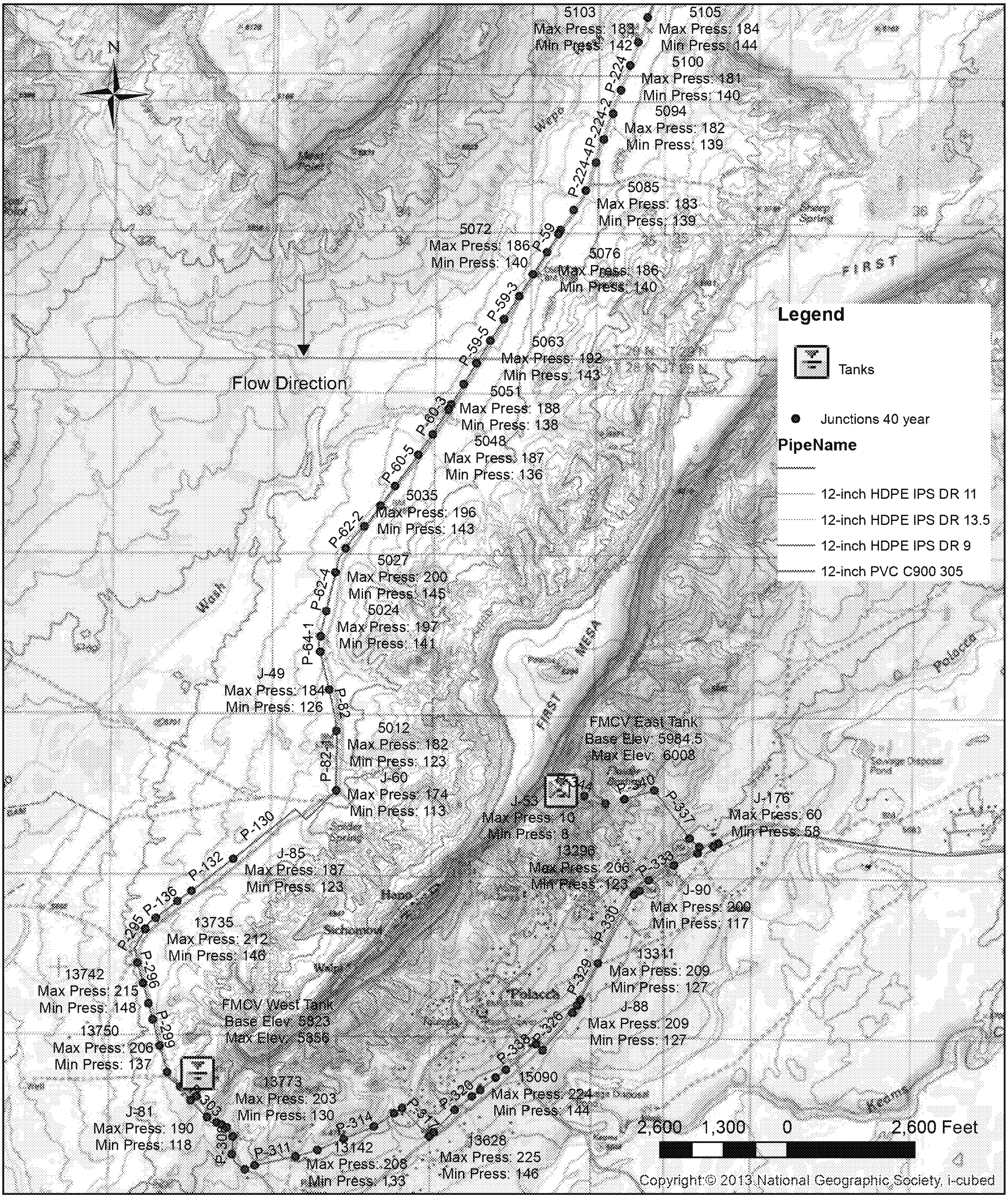
	Indian Health Service Office of Environmental Health & Engineering	**Phx Area IHS-Eastern Arizona District - Polacca Office** **HAMP-IHS Project PH 18-V31** **Updated Alternative A Regional Water Pressure Map** **Hopi Turquiose Trail Well System**
INDIAN HEALTH SERVICE · PHS · 1955	Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	Date: 7/6/18 Drawn By: NRC Checked By: JPC pg. 15



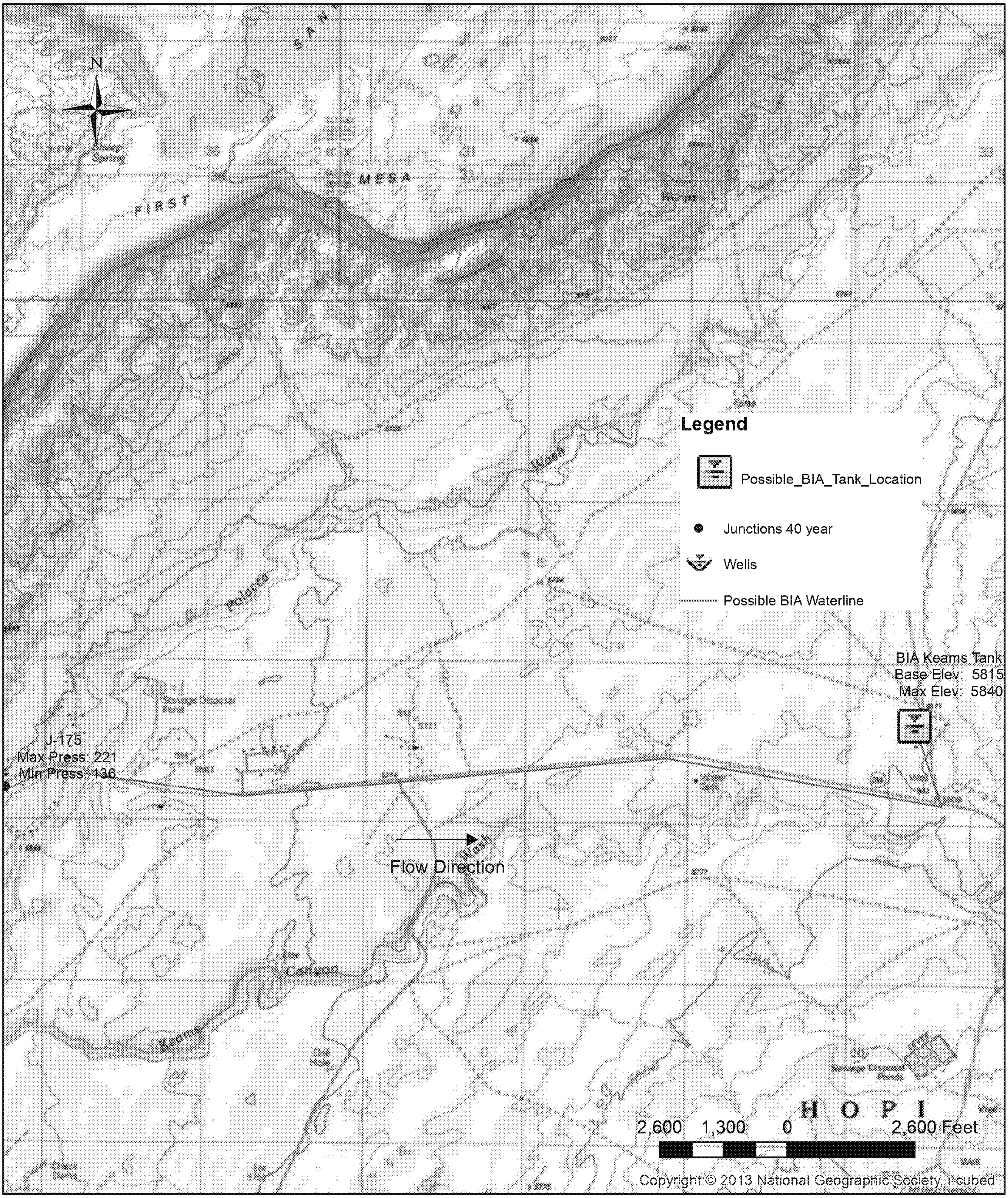
Indian Health Service Office of Environmental Health & Engineering Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	**Phx Area IHS-Eastern Arizona District - Polacca Office** **HAMP-IHS Project PH 18-V31** **Updated Alternative A Regional Water Pressure Map** **Hopi Tank #1 System**	
	Date: 7/6/18 Drawn By: NRC	Checked By: JPC



INDIAN HEALTH SERVICE · PHS · 1955	Indian Health Service Office of Environmental Health & Engineering	**Phx Area IHS-Eastern Arizona District - Polacca Office** **HAMP-IHS Project PH 18-V31** **Updated Alternative A Regional Water Pressure Map** **Hopi Tank 1 System Map 2 of 3**
	Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	Date: 7/6/18 Drawn By: NRC
		Checked By: JPC pg. 17



	Indian Health Service Office of Environmental Health & Engineering	**Phx Area IHS-Eastern Arizona District - Polacca Office** **HAMP-IHS Project PH 18-V31** **Updated Alternative A Regional Water Pressure Map** **Hopi Tank 1 System Map 3 of 3 in First Mesa**
INDIAN HEALTH SERVICE · PHS · 1955 ·	Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	Date: 7/6/18 Drawn By: NRC Checked By: JPC pg. 18



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Phx Area IHS-Eastern Arizona District - Polacca Office
HAMP-IHS Project PH 18-V31
Updated Alternative A Regional Water Pressure Map
Hopi BIA KeamsTank System Map

Date: 7/6/18
Drawn By: NRC

Checked By: JPC
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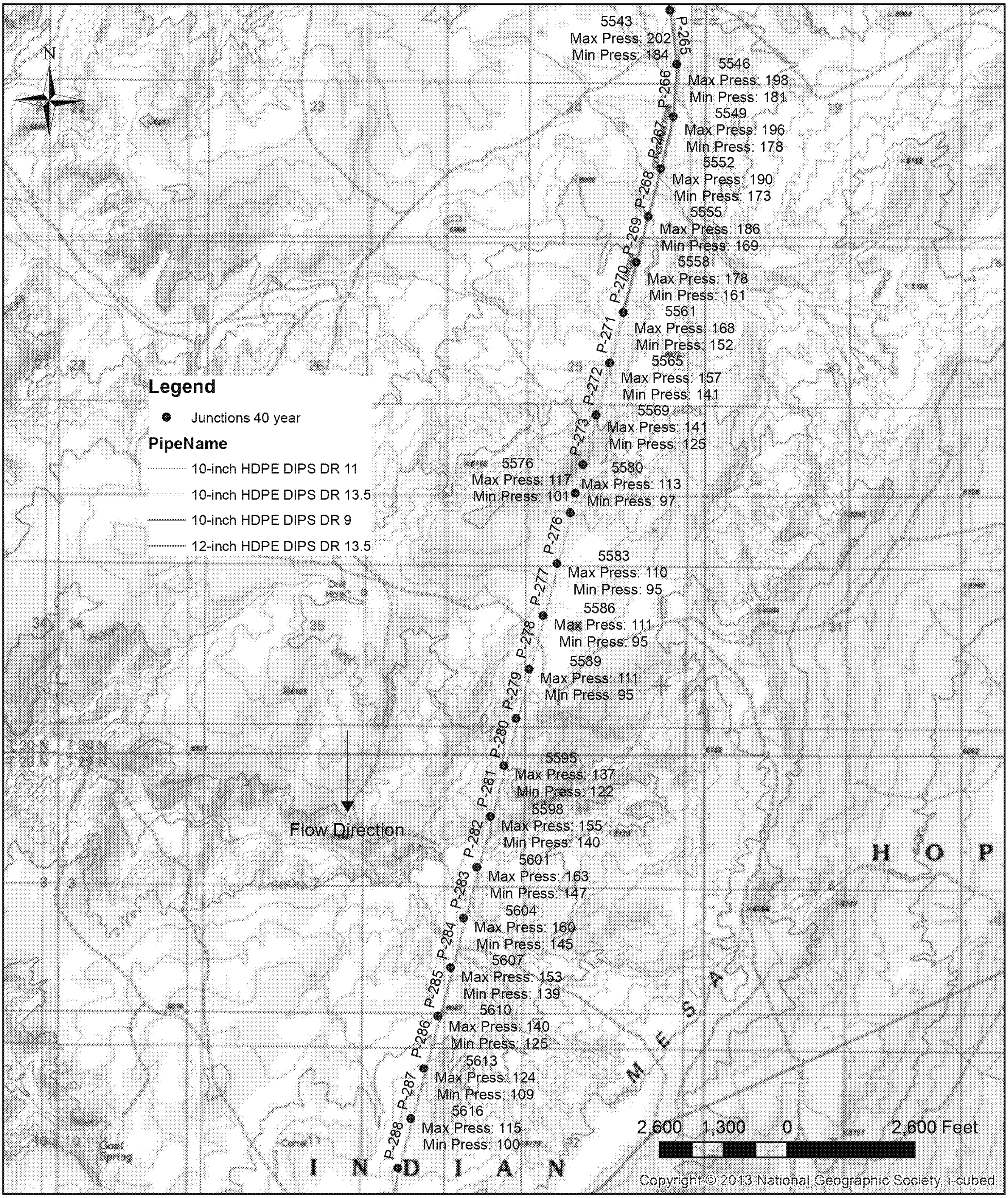

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Phx Area IHS-Eastern Arizona District - Polacca Office
HAMP-IHS Project PH 18-V31
Updated Alternative A Regional Water Pressure Map
Hopi Booster System 1 of 4

Date: 7/6/18
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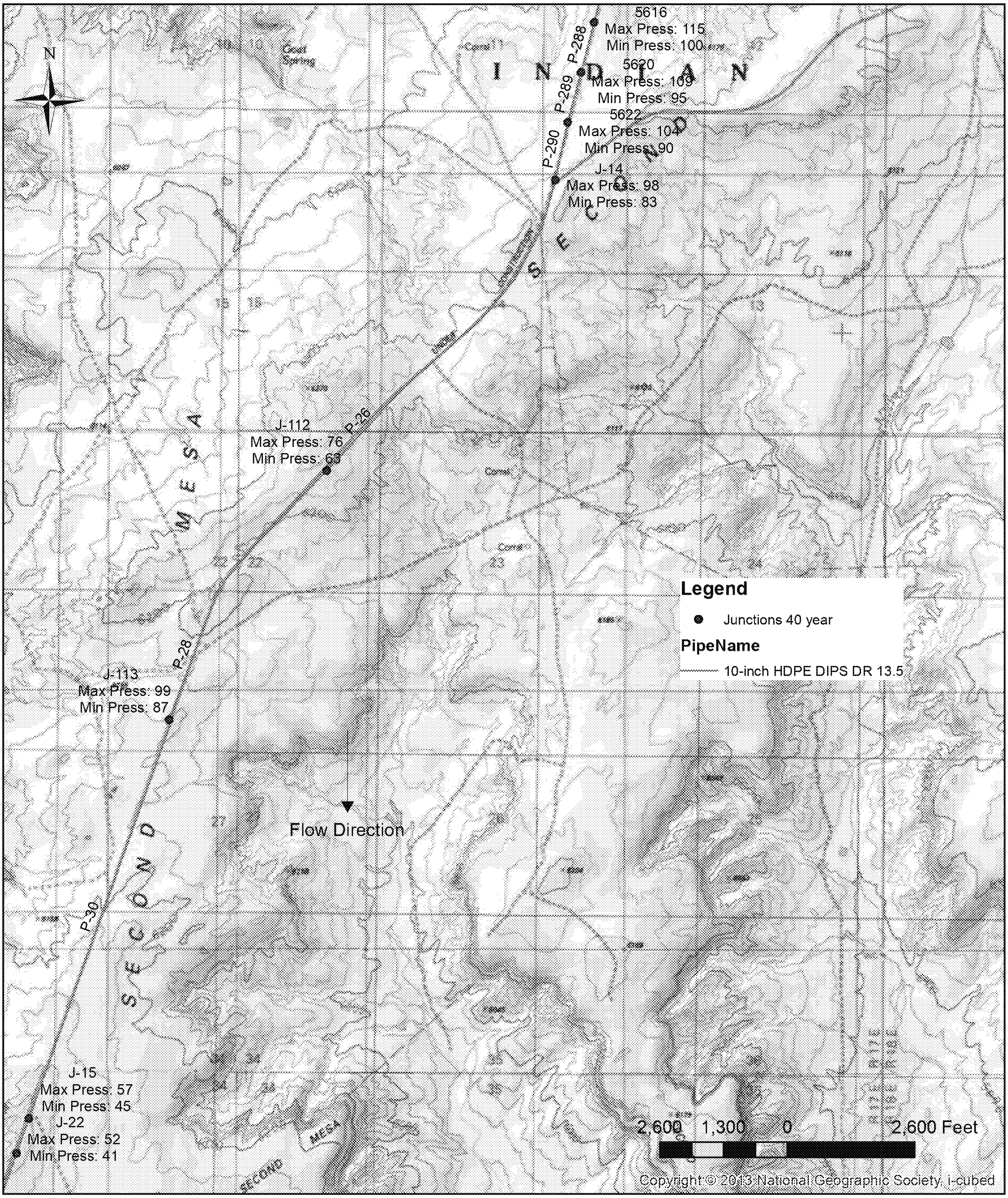
Checked By: JPC



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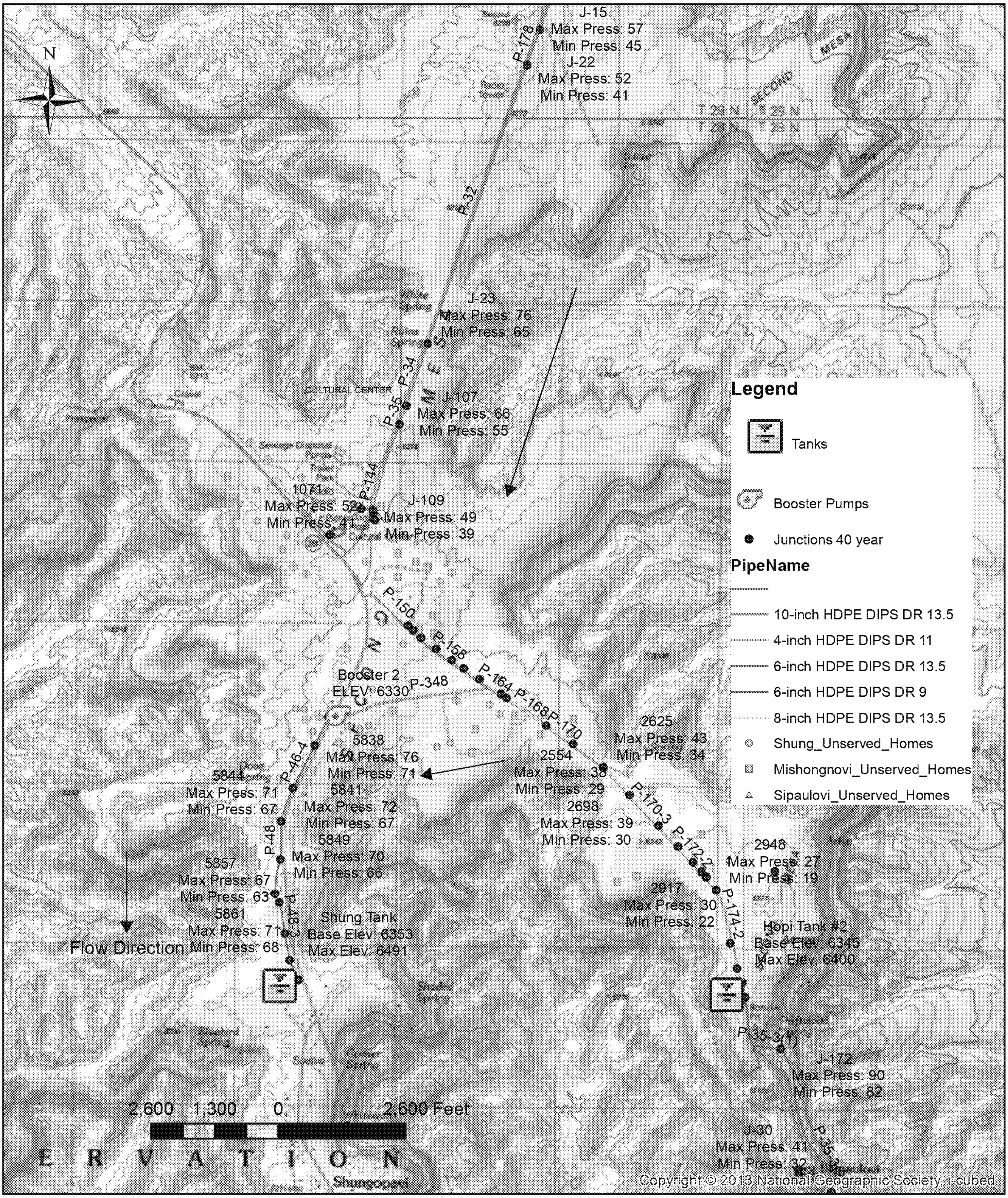
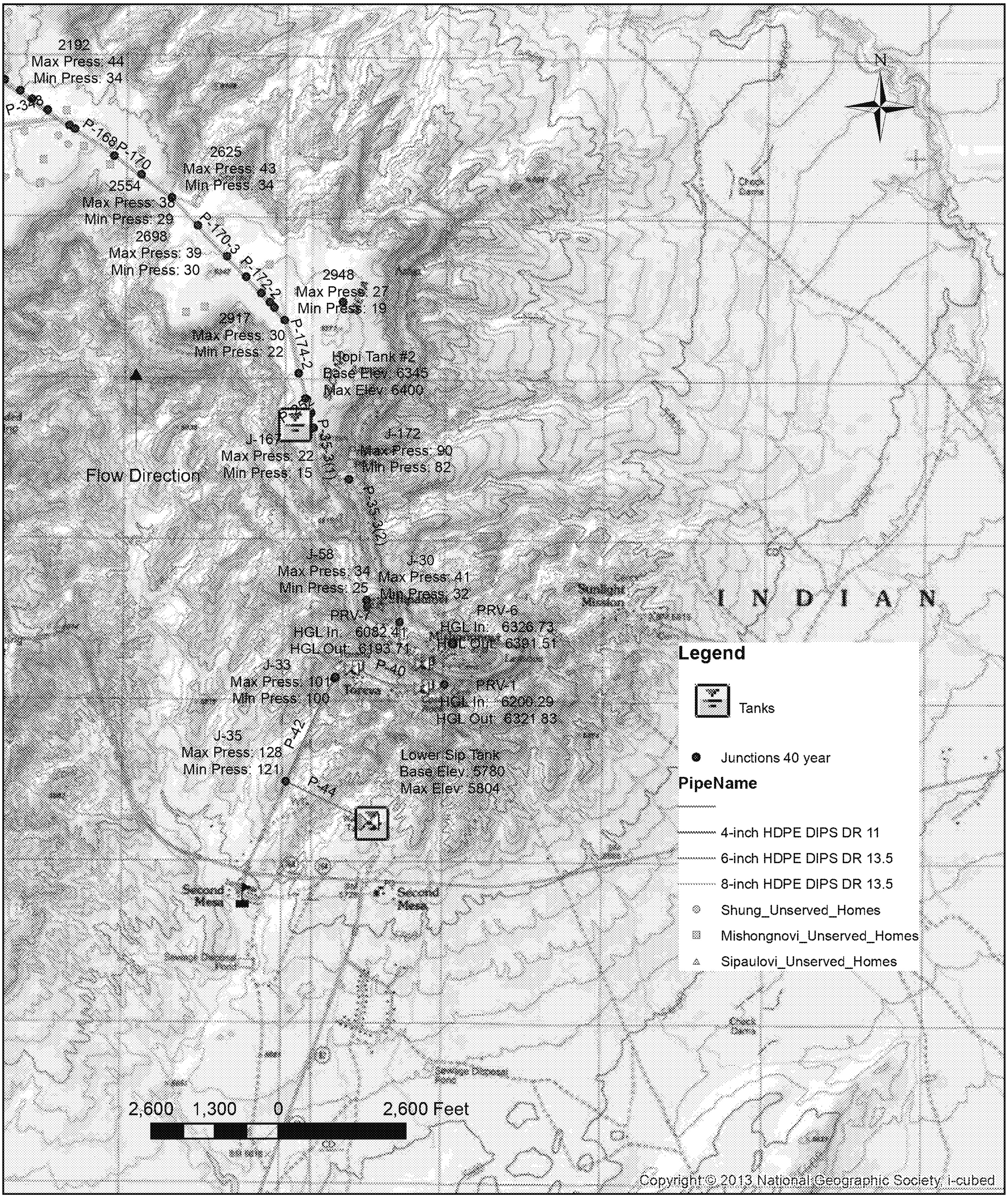
Updated Alternative A Regional Water Pressure Map
Hopi Booster System 2 of 3

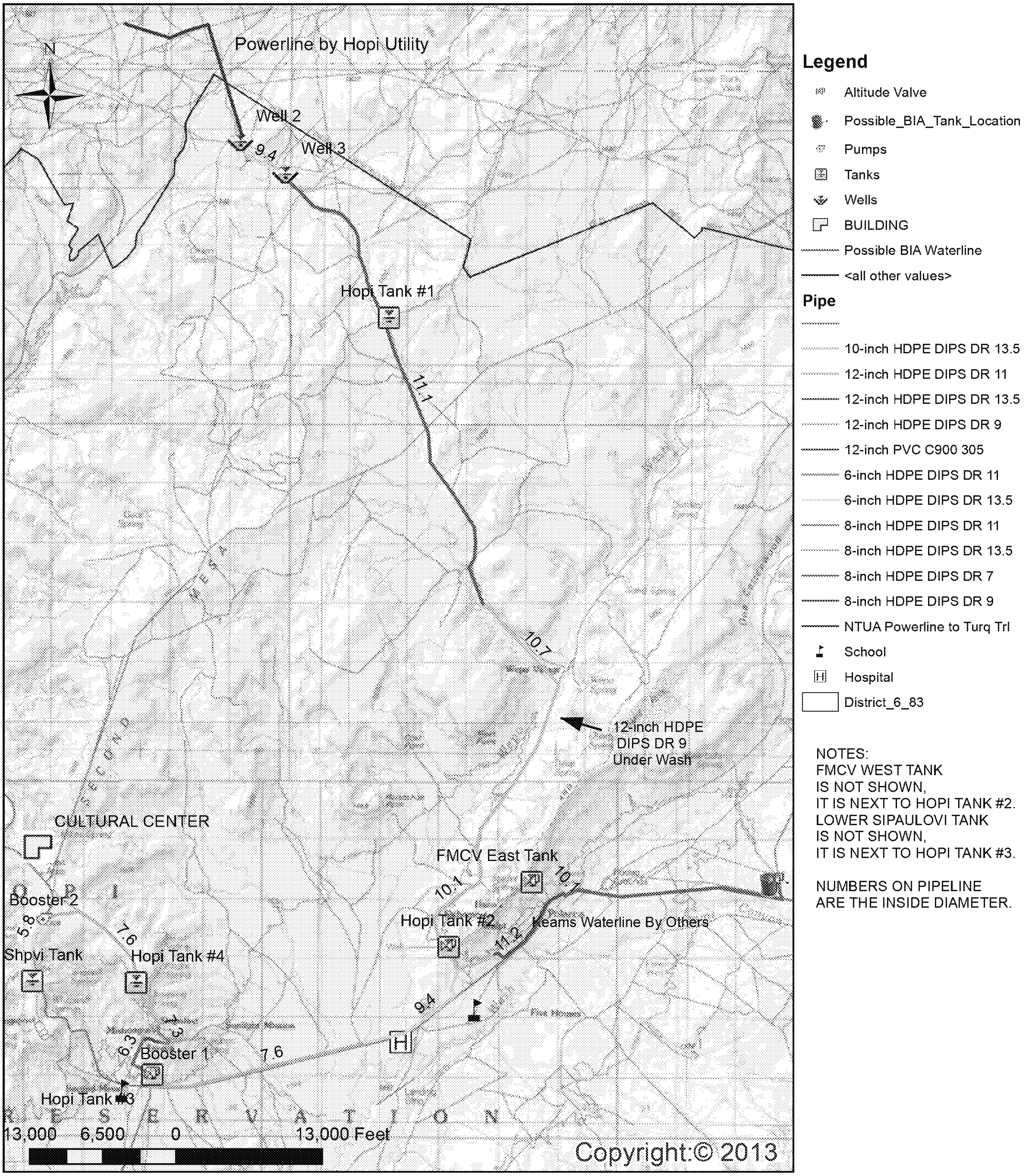
Date: 7/6/18	Checked By: JPC
Drawn By: NRC	pg. 21



INDIAN HEALTH SERVICE · PHS · 1955	Indian Health Service Office of Environmental Health & Engineering	**Phx Area IHS-Eastern Arizona District - Polacca Office** **HAMP-IHS Project PH 18-V31** **Updated Alternative A Regional Water Pressure Map** **Hopi Booster System 3 of 3** **Hopi Tank 2 and Booster 2 System in 2nd Mesa**	
	Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	Date: 7/6/18 Drawn By: NRC	Checked By: JPC pg. 22



Indian Health Service Office of Environmental Health & Engineering Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	**Phx Area IHS-Eastern Arizona District - Polacca Office** **HAMP-IHS Project PH 18-V31** **Updated Alternative A Regional Water Pressure Map** **Hopi Tank 2 System in Second Mesa**	
	Date: 7/6/18 Drawn By: NRC	Checked By: JPC pg. 23

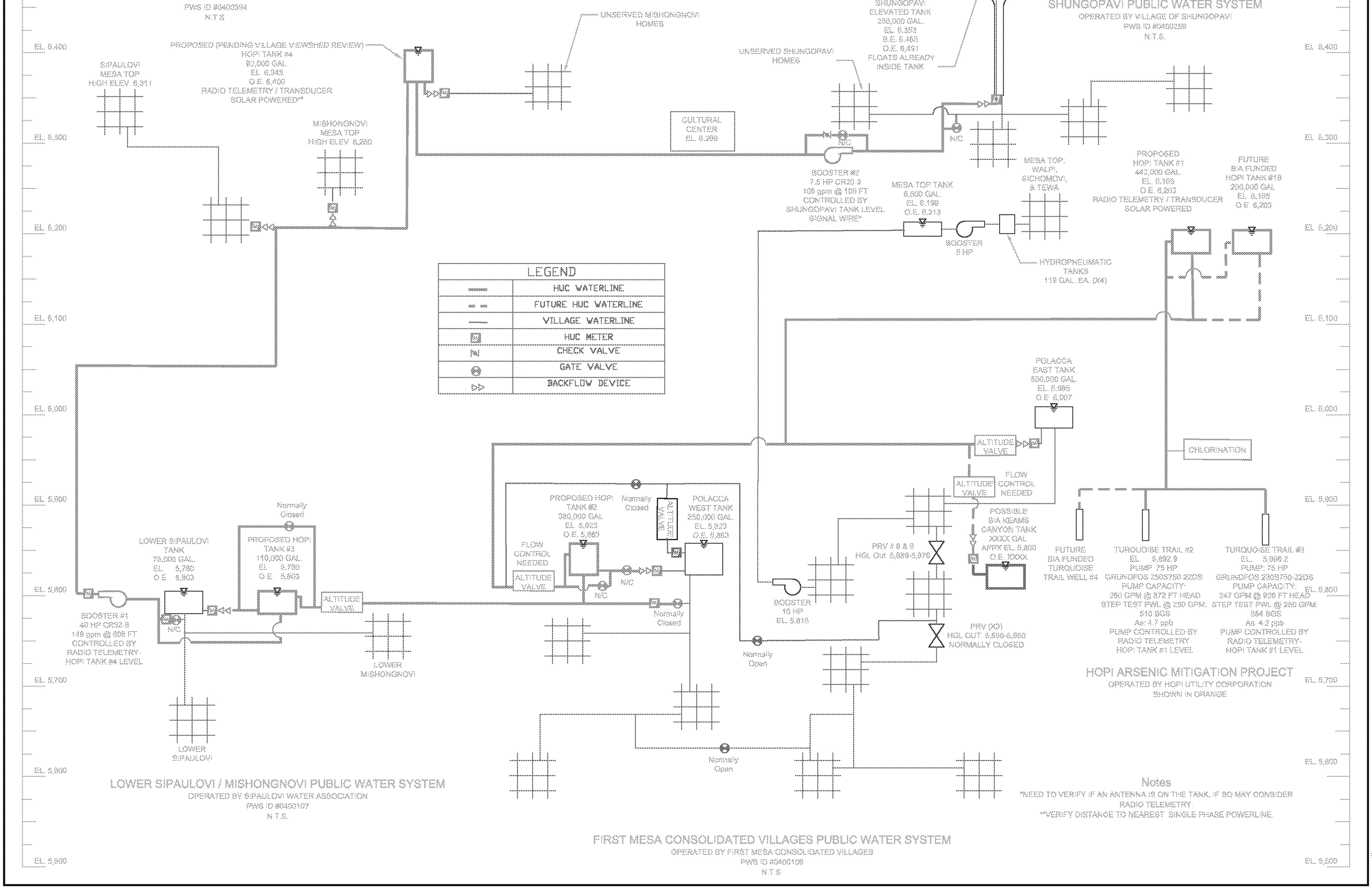


NOTES:
FMCV WEST TANK
IS NOT SHOWN,
IT IS NEXT TO HOPI TANK #2.
LOWER SIPAULOVI TANK
IS NOT SHOWN,
IT IS NEXT TO HOPI TANK #3.

NUMBERS ON PIPELINE
ARE THE INSIDE DIAMETER.

INDIAN HEALTH SERVICE · PHS · 1955 ·	Indian Health Service Office of Environmental Health & Engineering Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	**Phx Area IHS-Eastern Arizona District - Polacca Office Hopi Arsenic Mitigation Project Updated Alternative B Regional Water System Map IHS SDS Project AZ09981-0601** Date: 6/25/18 Drawn By: JPC pg. 24

PROPOSED RURAL WATER SYSTEM FACILITIES SCHEMATIC
UPDATED ALTERNATIVE B



DATE	REVISIONS	INIT
	pg. 25	

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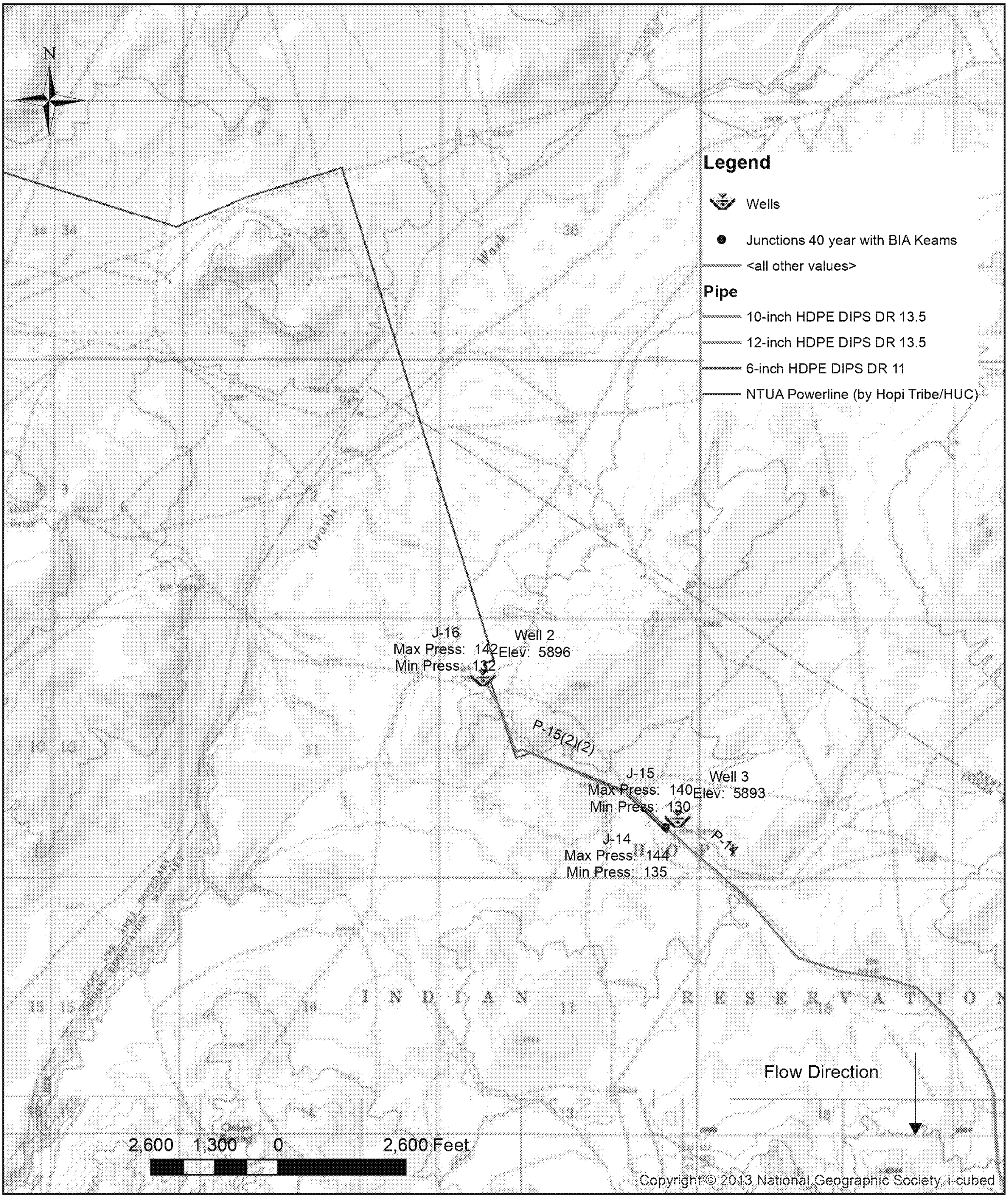
HOPI RESERVATION - NAVAJO COUNTY, ARIZONA
HOPI ARSENIC MITIGATION PROJECT
EXISTING FACILITIES SCHEMATICS
PH 18-V31

IA NUMBER: ---- SCALE: AS NOTED FILE NAME: HAMP-G-SCHEMATIC 10K REVISED
DRAWN BY: JPC DATE: 07-2018 LAYOUT NAME: G-101 ALT B
CHECKED BY: B.S./T.H. DATE: 08-2018 PROJ ENG: JAMES CARTER

G-101 Alt B
SHEET 03 OF 24



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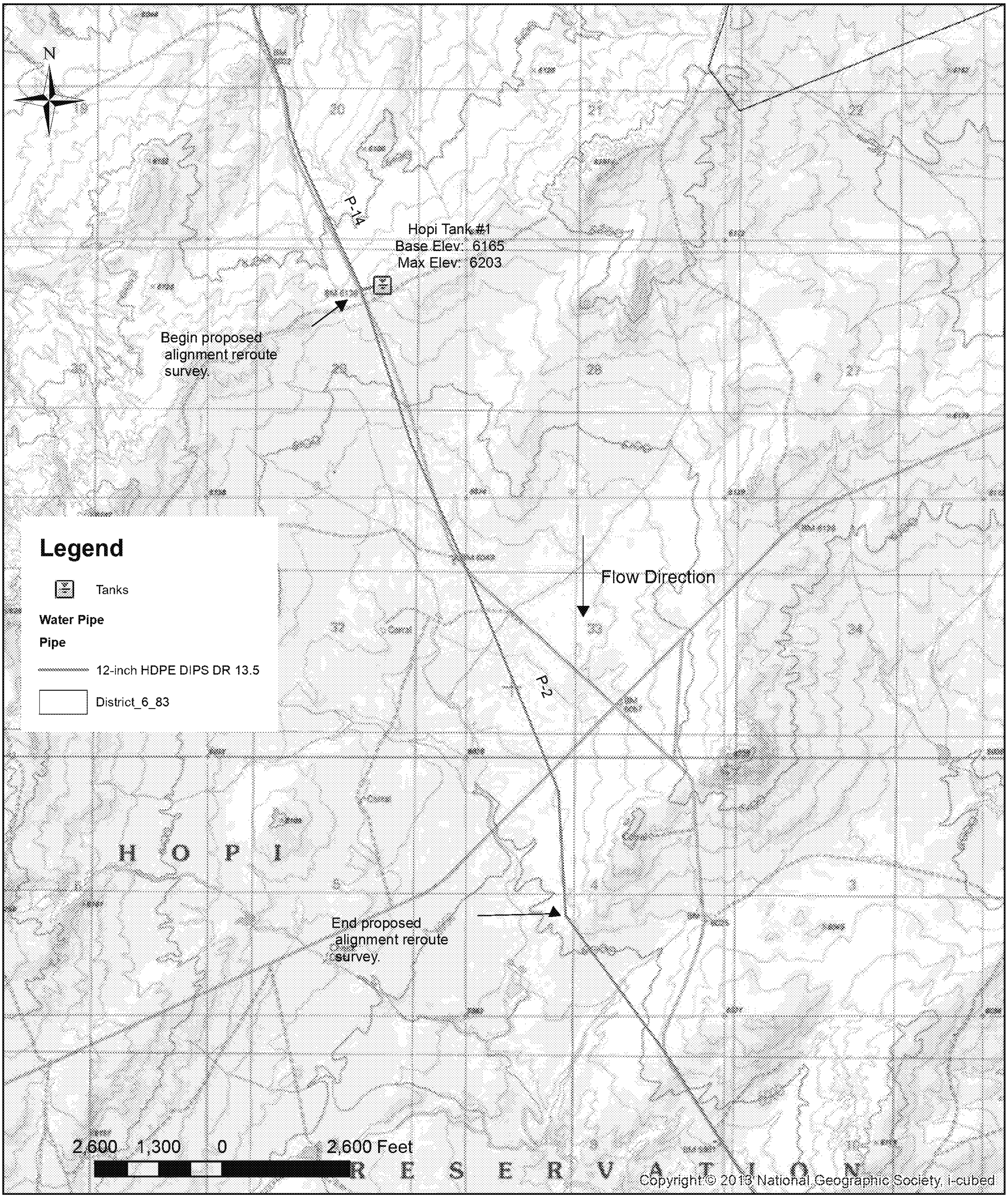
Phx Area IHS-Eastern Arizona District - Polacca Office
HAMP-IHS Project PH 18-V31
Updated Alternative B Regional Water Pressure Map
Hopi Turquiose Trail Well System

Date: 7/4/18
Drawn By: JPC



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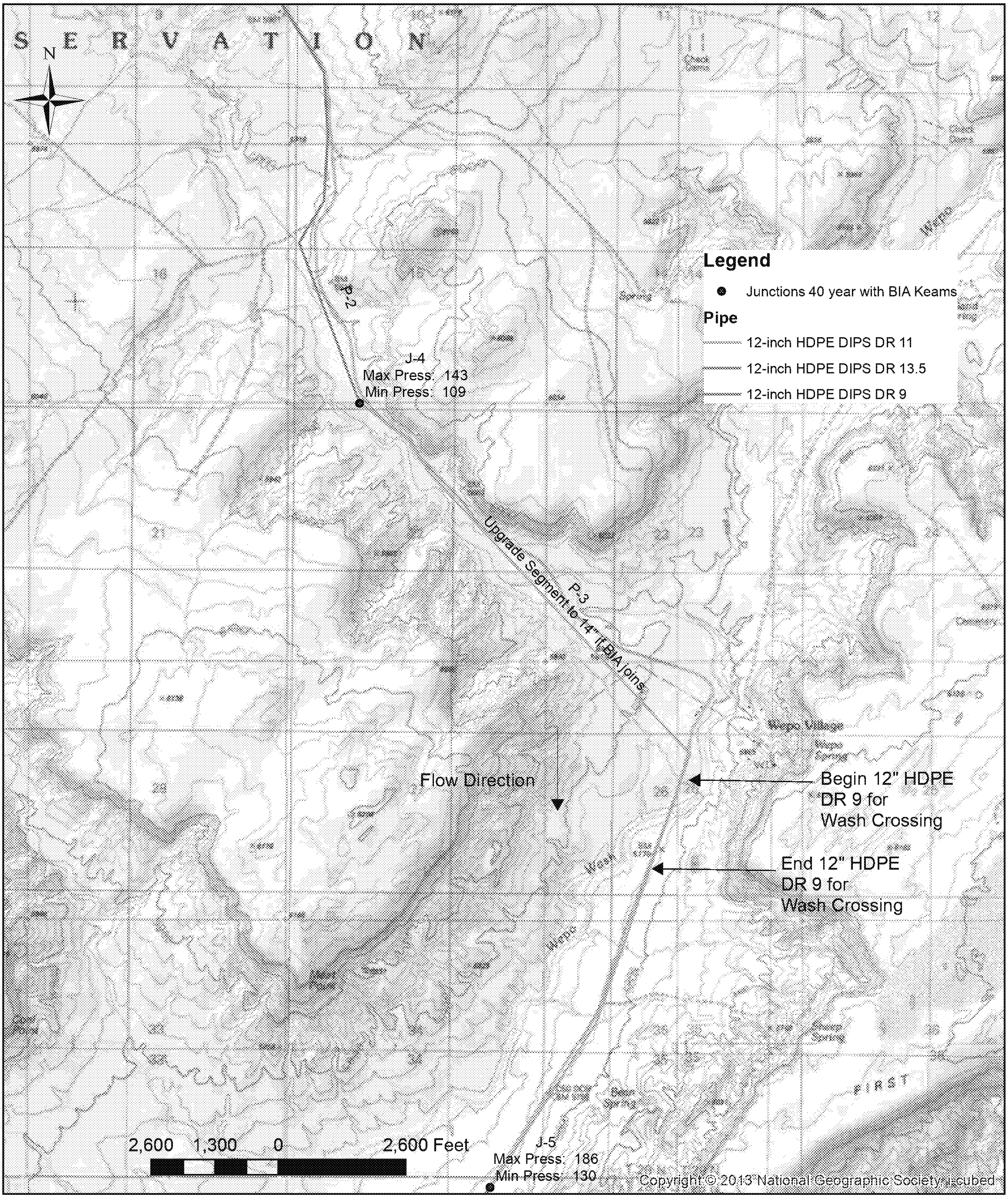
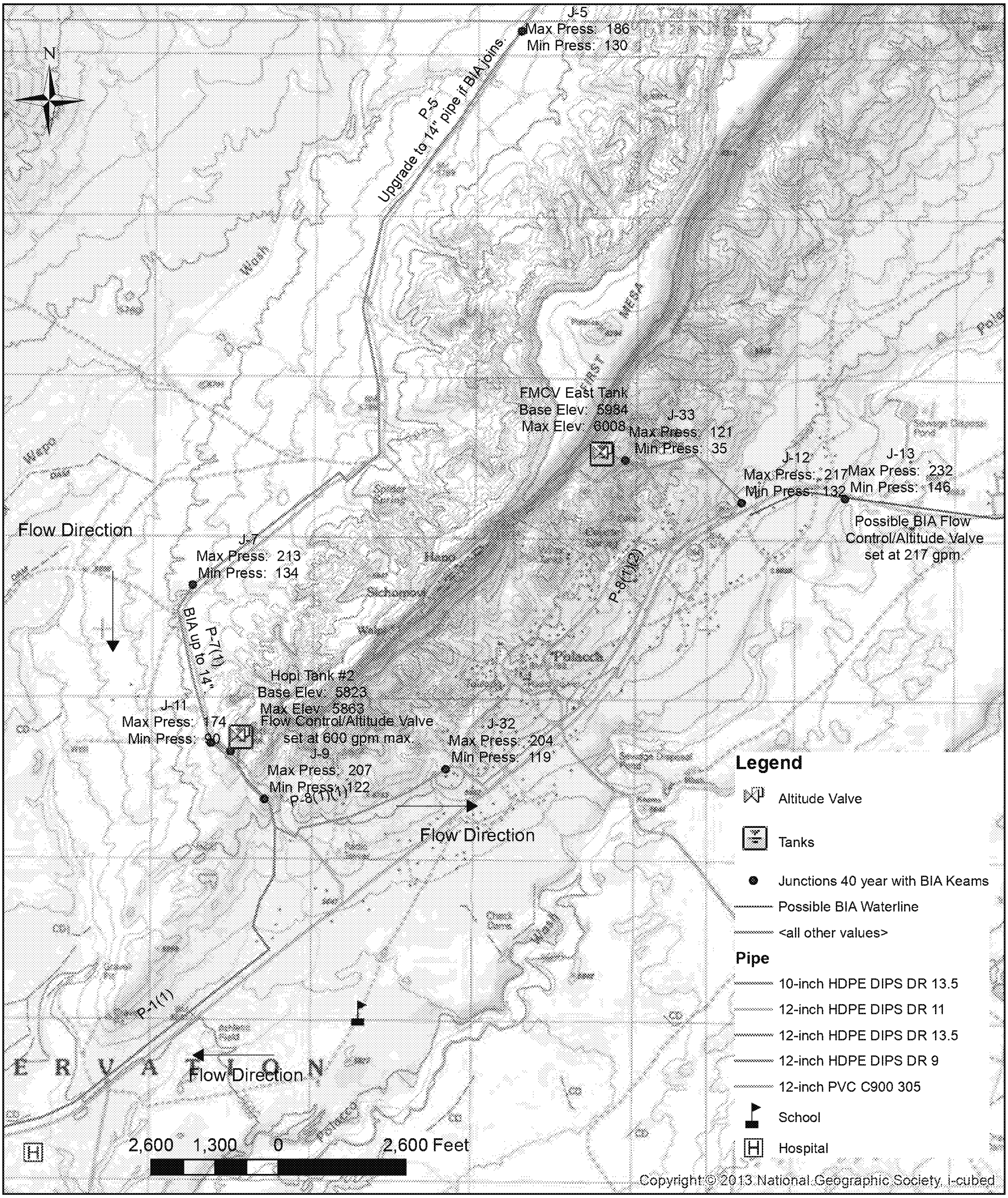
Phx Area IHS-Eastern Arizona District - Polacca Office
HAMP-IHS Project PH 18-V31
Updated Alternative B Regional Water Pressure Map
Hopi Tank 1 System: Map 1 of 2

Date: 7/4/18

Drawn By: JPC



INDIAN HEALTH SERVICE · PHS · 1955	Indian Health Service Office of Environmental Health & Engineering	**Phx Area IHS-Eastern Arizona District - Polacca Office** **HAMP-IHS Project PH 18-V31** **Updated Alternative B Regional Water Pressure Map** **Hopi Tank 1 System: Map 2 of 2**
	Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	Date: 7/4/18 Drawn By: JPC — pg. 28



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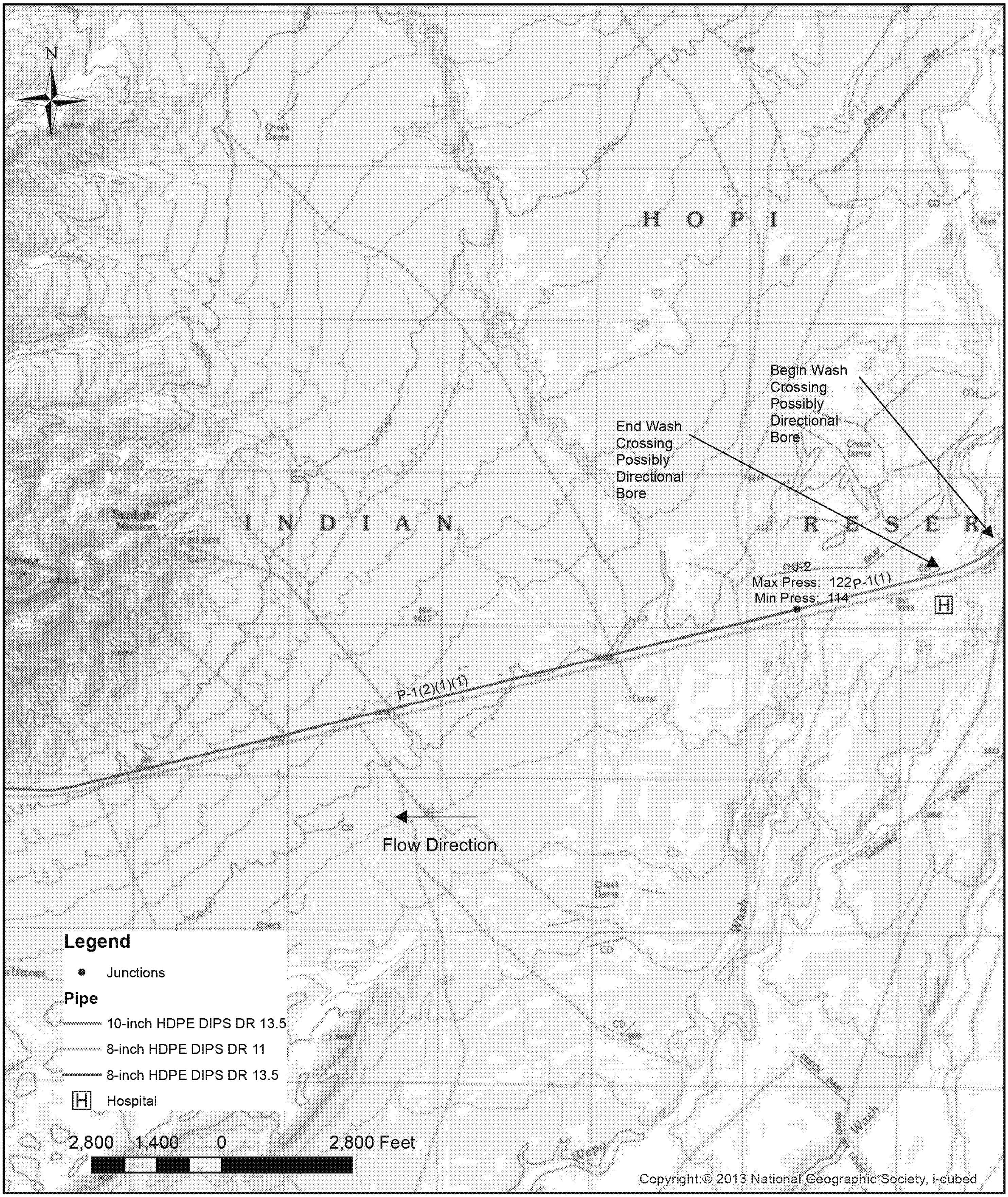
Phx Area IHS-Eastern Arizona District - Polacca Office
HAMP-IHS Project PH 18-V31
Updated Alternative B Regional Water Pressure Map
Hopi Tank 1 & 2 System at First Mesa

Date: 7/4/18

Drawn By: JPC



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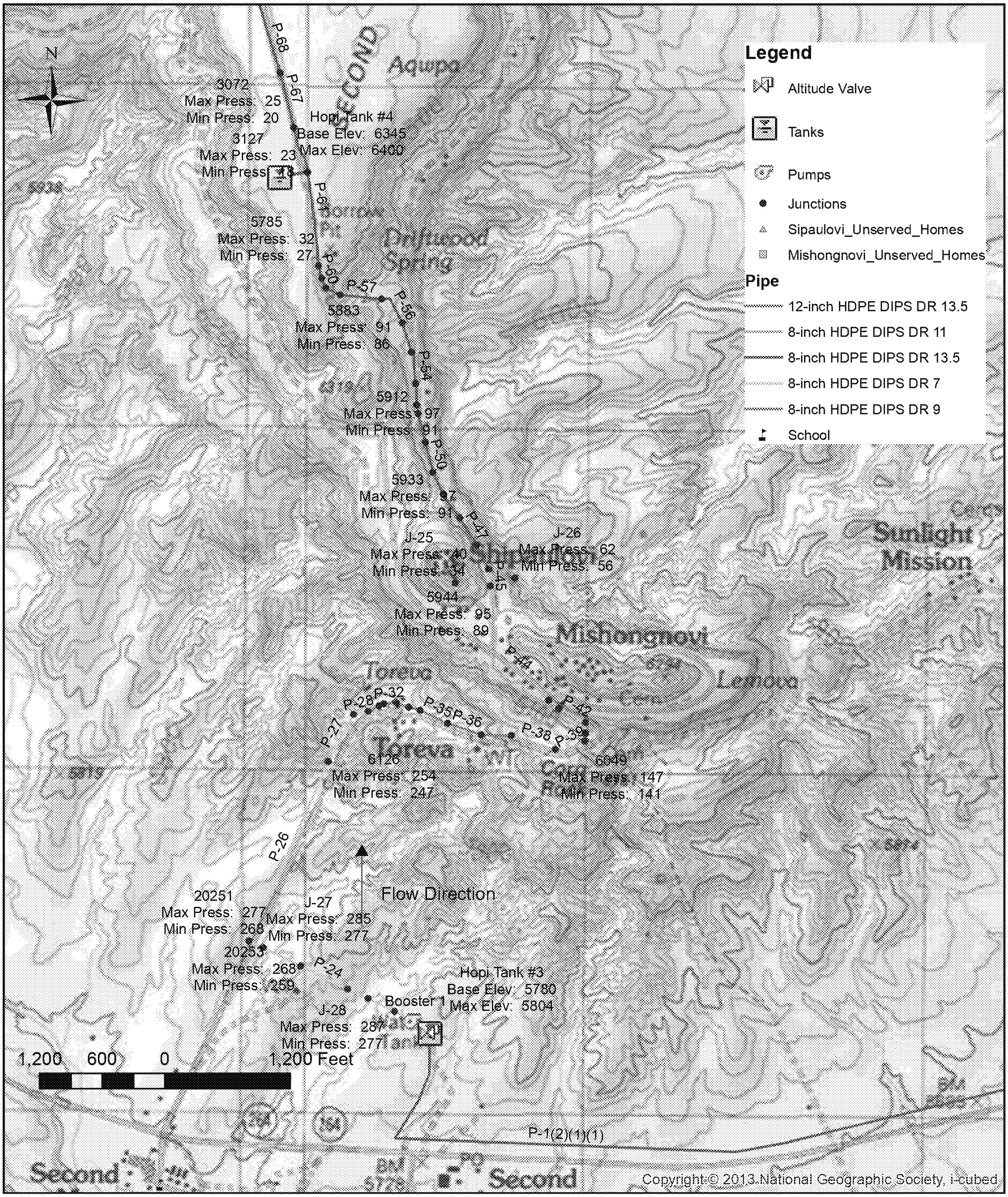
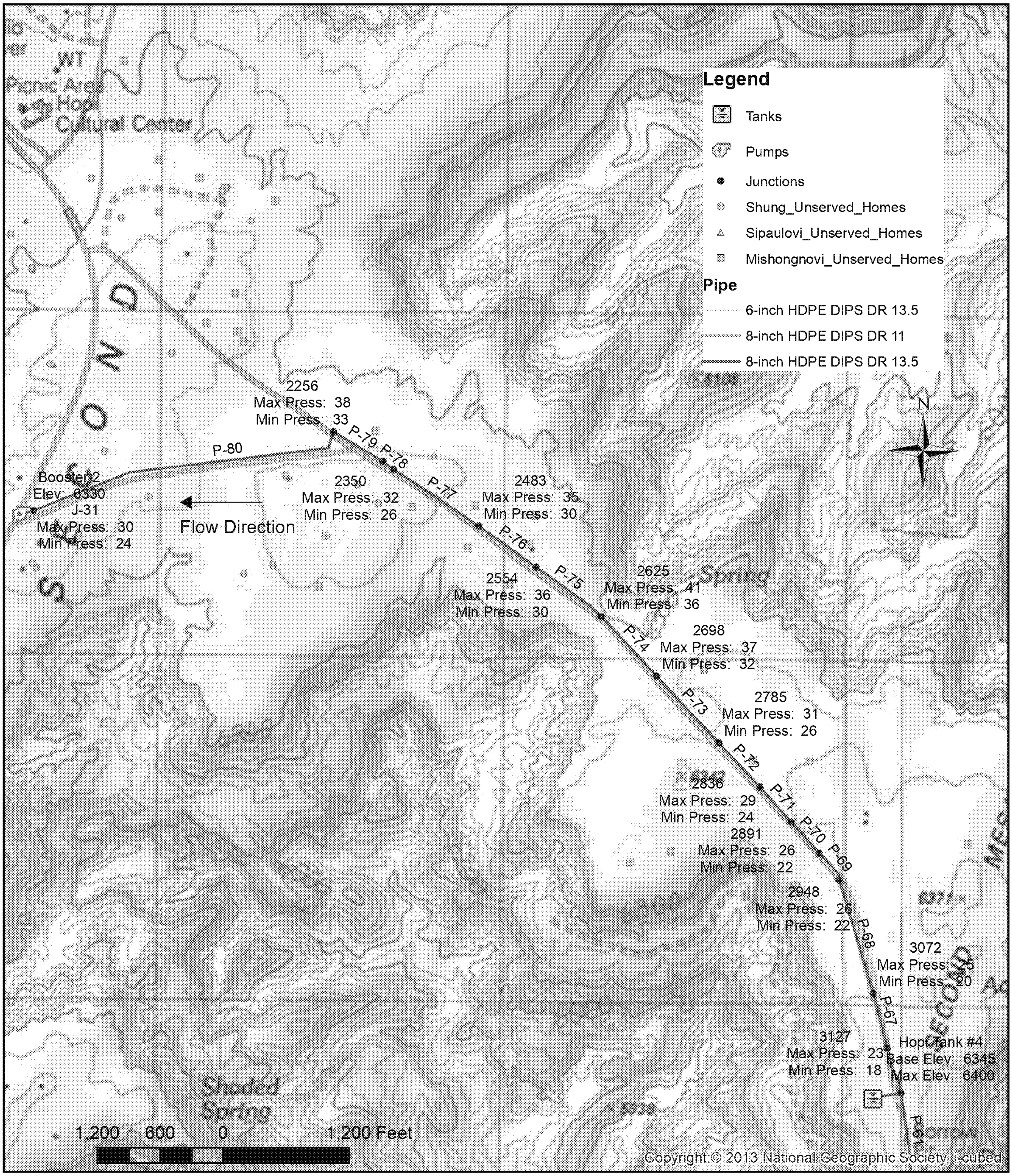


Indian Health Service Office of Environmental Health & Engineering Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	**Phx Area IHS-Eastern Arizona District - Polacca Office** **HAMP-IHS Project PH 18-V31** **Updated Alternative B Regional Water Pressure Map** **Hopi Booster 1 System at Second Mesa**	
	Date: 6/25/18 Drawn By: JPC	pg. 31



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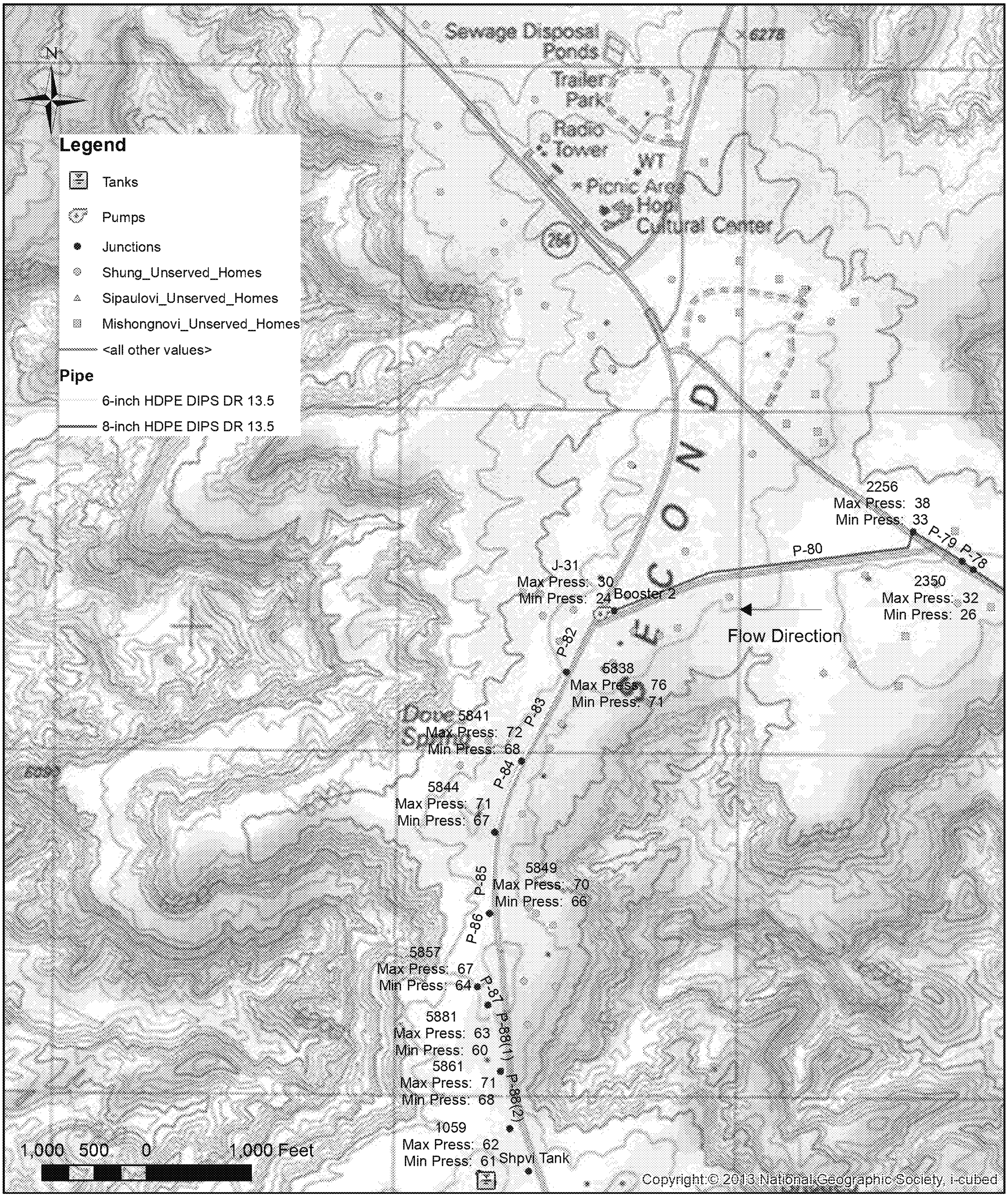
Phx Area IHS-Eastern Arizona District - Polacca Office
HAMP-IHS Project PH 18-V31
Updated Alternative B Regional Water Pressure Map
Hopi Tank 4 System at Second Mesa

Date: 6/25/18
Drawn By: JPC



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Phx Area IHS-Eastern Arizona District - Polacca Office
HAMP-IHS PH 18-V31
Updated Alternative B Regional Water Pressure Map
Hopi Booster 2 System

Date: 6/25/18
Drawn By: JPC

WATER SYSTEM DESIGN ANALYSIS

Date: 7/3/2018 System: Hopi Pres. Zone: Hopi___Project No. PH 18-V31 HAMP
Voltage/Phase Available: 480/3-phase Supplier: Navajo Tribal Utility Authority

EXISTING SYSTEM

Water Production

FROM OPERATING UTILITY	Daily Total Usage	202,425	GPD
	Less Daily Demand of Schools & Business	18,491	GPD
	Daily Domestic Water Usage (2017)	186,934	GPD
(Existing No. of Services 778)	Avg Service Usage	240	GPHD

IF ACTUAL USAGE RATES UNAVAILABLE

No. of homes	___ x 240*GPHD =	___	GPD
No. of Students			
Elementary	___ x 20 GPSD =	___	GPD
High School	___ x 40 GPSD =	___	GPD
Boarding	___ x 60 GPSD =	___	GPD
Business ___, ___, ___	=	___	GPD
TOTAL:		202,425	GPD

Water Storage

Total Storage Volume*	2,099,000	GAL
Less Fire Flow Reserve (from operating utility)	___	GAL
Total Useable Storage	___	GAL
Days of Storage (2,099,000/205,000)	10.36	DAYS

List of Tank Sizes: 1 @ 500,000 gallons FMCV East, 1 @ 250,000 gallon FMCV West, 1 @ 250,000 Shungo, 1@75,000 Lower Sip, 1 @ 442,000 Hopi #1, 1 @ 380,000 Hopi #2, 1 @ 110,000 Hopi #3, 1 @92,000 Hopi #4.

Water Source: Turquoise Trail Wells

EXISTING WELL & PUMP DATA FROM OPERATING UTILITY

Well No.	Casing Diam.	Depth	SWL	Max. Well Yield & Pumping Level	Design Pump & Pumping Level
2	12In.	2180 Ft.	440 Ft.	300 GPM @ 547Ft.	263GPM @525Ft. 860 TDH*75 HP
3	12In.	2241 Ft.	448 Ft.	321 GPM @ 598Ft.	256GPM @560Ft. 890 TDH*75 HP
___	___In.	___Ft.	___Ft.	___ GPM @ __Ft.	___GPM @__Ft. ___TDH* _ HP
___	___In.	___Ft.	___Ft.	___ GPM @ __Ft.	___GPM @__Ft. ___TDH* __HP

*TDH is calculated with both tanks at 80% full and does not include head losses.

TOTAL: GPM 519 GPM

Other sources, capability, and current production: None.

Average Daily Pumping Cycle: 202,425 GPD/519 GPM/60 M = 6.5 HR.

Water Distribution (Range of pressure of existing homes)

System Pressure:
Maximum (static) _ psi Location:___
Minimum (dynamic) _ psi Location:
Location of known pressure problems:

WATER SYSTEM DESIGN ANALYSIS

Date: 7/3/18 System: Hopi Pres. Zone: Hopi Project No. PH 18-V31 HAMP

ADDITIONS TO SYSTEM UNDER PROPOSED PROJECT

Water Production

No. of Additional Homes	91	x	200	GPHD	= 18,200	GPD
No. of Additional School Students						
Elementary	____	x	20	GPSD	= ____	GPD
High School	____	x	40	GPSD	= ____	GPD
Boarding School	____	x	60	GPSD	= ____	GPD
Business (Cult Cent)	____		6000 GPD		= 6000	GPD

Total Additional Water Usage	24,200	GPD
Present Usage	202,425	GPD
Total Usage After Project Completion	226,625	GPD

Water Storage (Additional Required?)

Total Storage Required After Project Completion 339,937 GAL

Total Existing Storage (See Page 1 for listing of tanks) 2,099,000 GAL

Existing Storage Adequate? /x/ Yes or / / No

Note: Large flows from Hopi Tank #1 justify larger tank there to keep the tank from emptying too rapidly. This tank also provides redundancy to FMCV East Tank.

If NO:

Total storage required (based on "Future Water Usage" below) 542,718 GAL

Total existing useable storage ____ GAL

Additional storage required/proposed 0 GAL

Water Source (Additional Required?)

Total capacity needed after project completion (226,625/ 12 / 60) 315 GPM

Total present pump capacity 519 GPM

Present pump capacity adequate? /x/ Yes or /_/ No

If NO: (and source adequate): Well # New Pump & Pumping Level

then a new pump required:

____ ___GPM @ ____ Ft., ____ TDH ____ HP

Other:

Present source adequate? /_x_/ Yes or /__/ No

If NO:

Source capability required (based on "Future Water Usage" below) 450 GPM

Present source capability 519 GPM

Additional source required ____ GPM

Water Distribution upon Project Completion

System Pressure:

Maximum (static) N/A psi Location: Downstream Hopi Booster #2

Minimum (dynamic) N/A psi Location: Near HUC Tank #4

Location of known pressure problems:

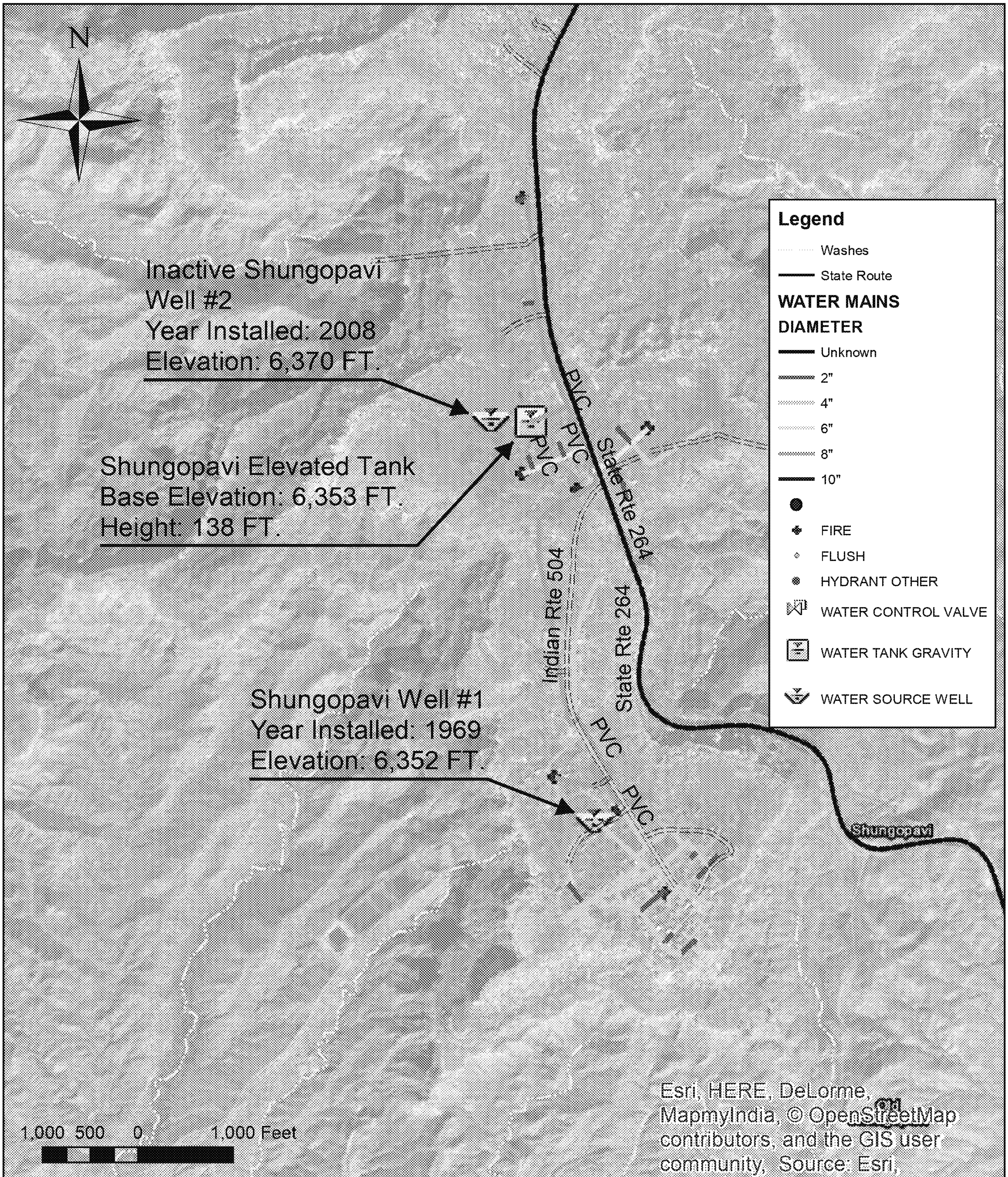
ESTIMATED POPULATION GROWTH FOR SIZING MAJOR IMPROVEMENTS (IF REQUIRED)

Growth Factor within next 1 years 1.8 %

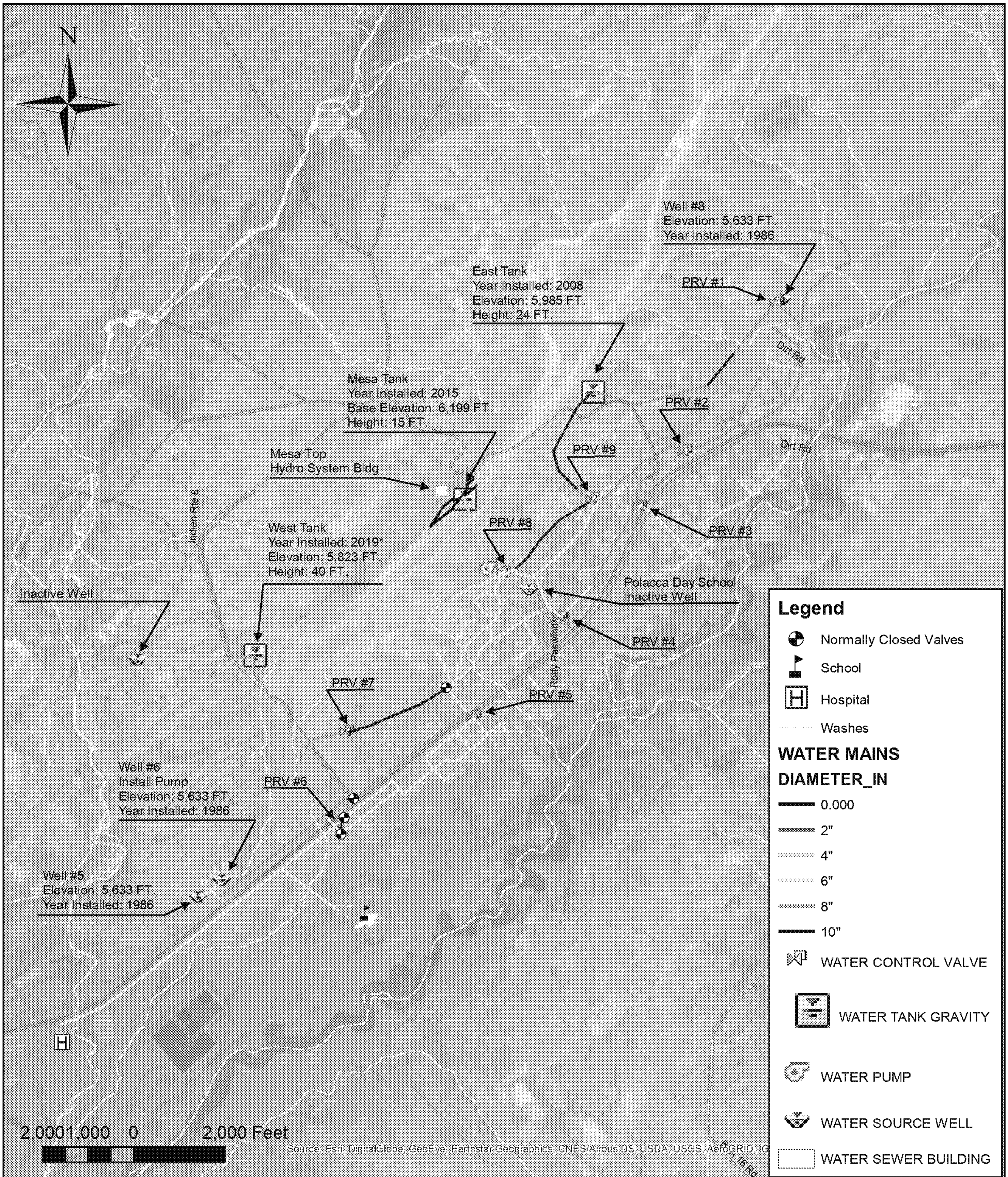
Present Water Usage (includes proposed project) 226,625 GPD

Future Water Usage (Year 2037) 323,791 GPD

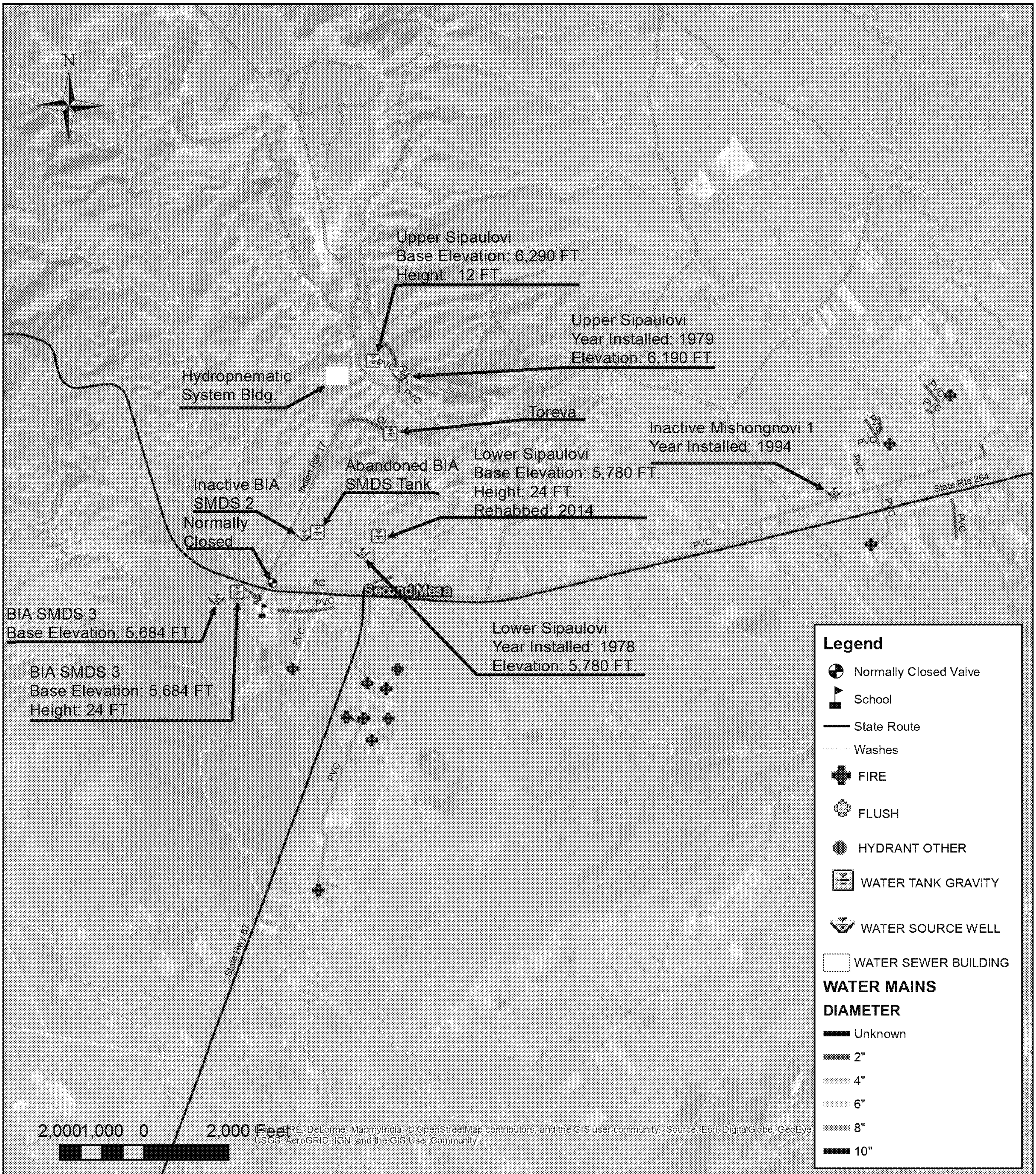
ITEMS NEEDED TO UPGRADE SYSTEM:



	Indian Health Service Office of Environmental Health & Engineering	**Phx Area IHS-Eastern Arizona District - Polacca Office** **Existing Facilities Map- IHS SDS Project AZ09981-0601** **Shungopavi Water System**
	Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	Date: 3/13/18 Drawn By: NRC — pg. 36



	Indian Health Service Office of Environmental Health & Engineering Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	**Phx Area IHS-Eastern Arizona District - Polacca Office** **Existing Facilities Map- IHS SDS Project AZ09981-0601 FMCV Water System** Date: 3/20/18 Drawn By: NRC pg. 37



	Indian Health Service Office of Environmental Health & Engineering	**Phx Area IHS-Eastern Arizona District - Polacca Office** **Existing Facilities Map- IHS SDS Project AZ09981-0601** **Sipaulovi & Mishongnovi Water System**
	Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	Date: 3/14/18 Drawn By: NRC

Table 1. Projected pumping water levels in HAMP Wells 2 and 3 based on predicted levels due to in-well drawdown only, shown in Figures 9 and 10, adjusted to reflect water-level-change predictions of Brown and Eychaner (1988) groundwater-flow model, Projection B, for observation well BM-5 (their fig. 23)

	HAMP Well 2			HAMP Well 3		
year	predicted level due to in-well drawdown only, ft	water-level rise after 2015, ft	adjusted pumping depth to water, ft	predicted level due to in-well drawdown only, ft	water-level rise after 2015, ft	adjusted pumping depth to water, ft
2015	642	0	642	661	0	661
2020	662	10	653	681	10	671
2025	680	17	663	698	17	681
2030	697	18	679	715	18	697
2035	715	17	698	732	17	715

PROJECTED CHANGE IN WATER QUALITY

Arsenic concentration has been measured over time in the Piñon NTUA No. 1 and Forest Lake NTUA No. 1 wells, as shown in Figure 11. The data for the plots are taken from the series of USGS progress reports cited by Macy and Unema (2013). The Piñon well is located in the area where aquifer leakage is predicted (see Fig. 2), and the Forest Lake well is essentially on the boundary of the possible leakage area suggested by Lopes and Hoffmann (1997, fig. 4). TDS concentration over time for each well is shown in Figure 12. As might be expected, TDS concentration in water from the Piñon well has risen from somewhat less than 300 mg/L to more than 422 mg/L during the 29 years shown, while the TDS content of water from the Forest Lake well has varied over a wider range but without an evident trend.

Arsenic concentration appears to have increased in both the Piñon and Forest Lake wells, and at about the same rate, about 0.05 µg/L per year, although the production rates from the two wells are significantly different. Although the potential for leakage into the N aquifer in the vicinity of the HAMP wells is not completely understood, it would appear that the concentration in the D aquifer, at 2.9 µg/L, is less than in the N aquifer. Given that the concentrations in zones within the N aquifer are similar to each other, in the range 4.1 to 4.8 µg/L in HAMP Well 2, and that the concentrations in waters from the finished wells are within that range, it seems likely that, even if leakage occurs, arsenic concentrations would not rise above about 4.8 µg/L and might in fact decline.

regional drawdown rate. The estimates, based on the Theis equation, do not account for leakage or variation in N-aquifer properties from place to place. The predicted pumping water level, at a constant rate of 350 gpm, 705 ft represents about 20 percent of the total available drawdown above the top of the well screen.

A separate report with predicted future pumping water levels, accounting for projected demand and the impacts of regional pumping, is in preparation. Recognizing the uncertainties in the calculations, the pump setting depth should be substantially greater than the predicted pumping water level.

Table 9. Summary of long-term pumping level estimates assuming no regional water-level change, HAMP Well No. 2, Hopi Tribe, Arizona

pumping rate, constant, gpm	starting water level, ft bgl	100-min specific capacity, gpm/ft	100-min drawdown, ft bgl	5 years			40 years		
				regional drawdown, ft	additional drawdown after 100 min, ft bgl	pumping water level, ft bgl	regional drawdown, ft	additional drawdown after 100 min, ft	pumping water level, ft bgl
175	445	2.94	60	0	51	556	0	62	542
200	445	2.89	69	0	59	573	0	70	584
250	445	2.77	90	0	73	608	0	88	623
300	445	2.66	113	0	88	646	0	106	664
350	445	2.55	137	0	102	684	0	123	705
415	445	2.40	173	0	121	739	0	146	764

ft bgl - feet below ground level
gpm - gallons per minute

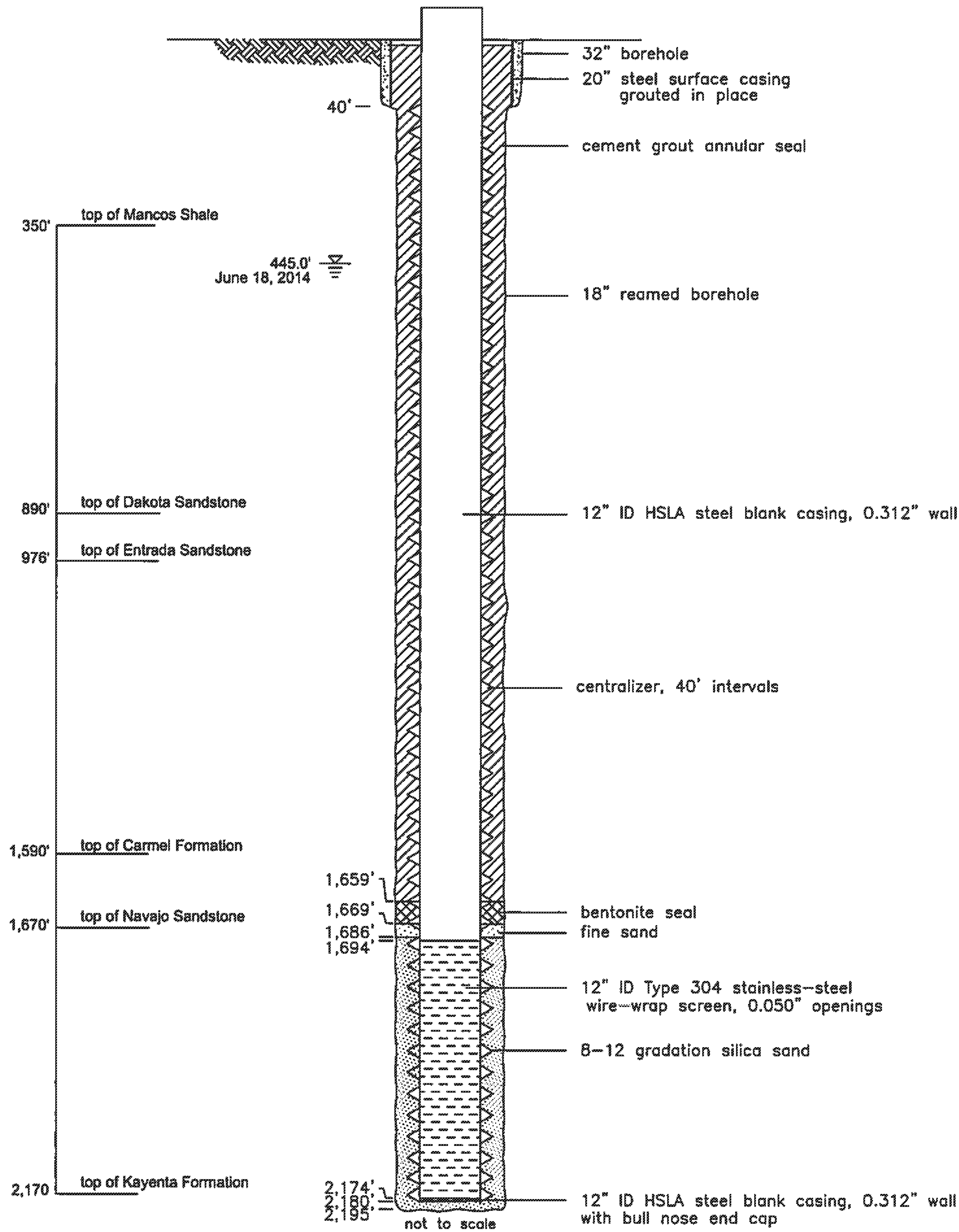


Figure 3. Well completion diagram, HAMP Well No. 2, Hopi Tribe, Arizona.

09/04/2014

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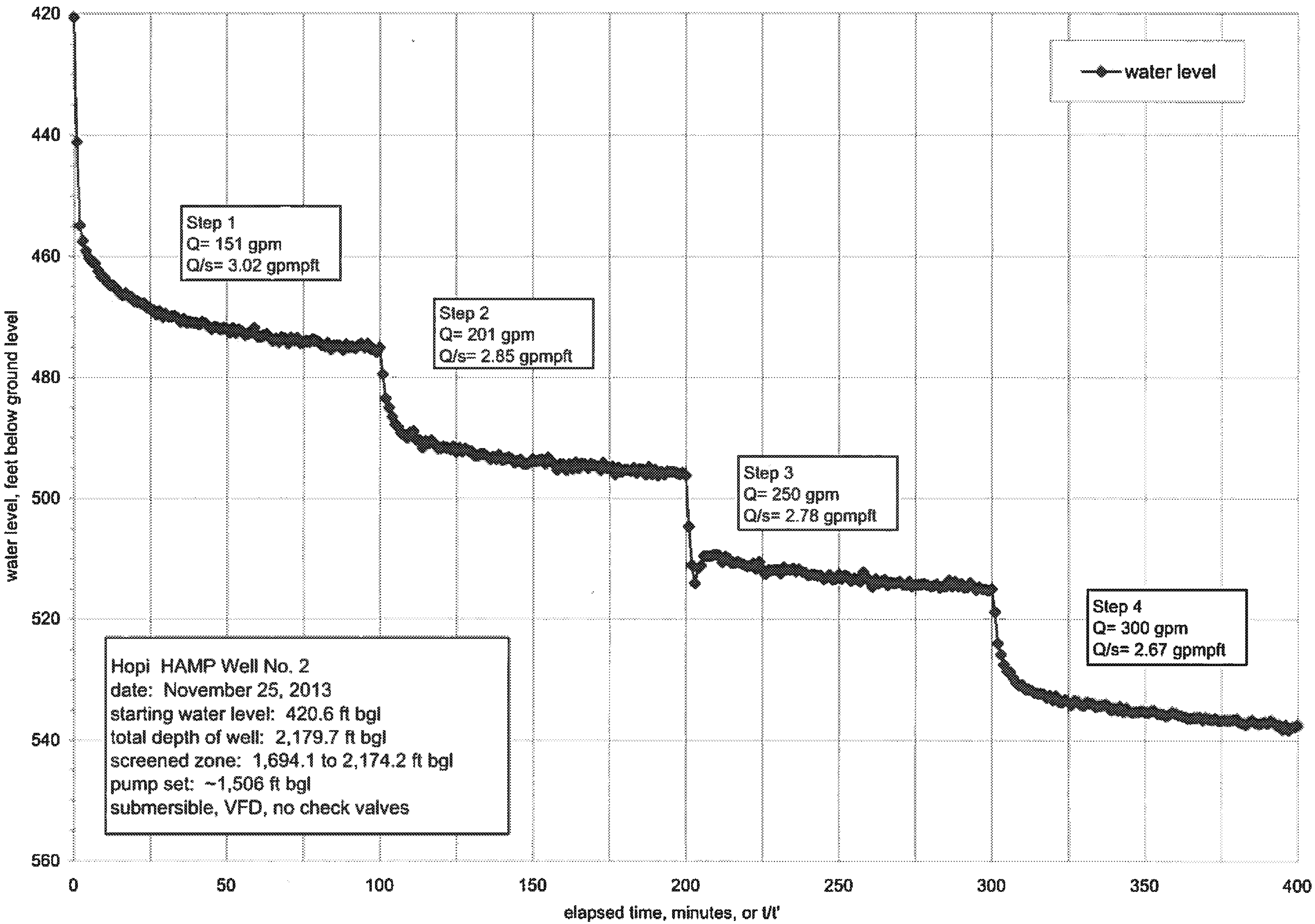

Figure 4. Graph showing results of step-drawdown pumping test, HAMP Well No. 2, Hopi Tribe, Arizona.

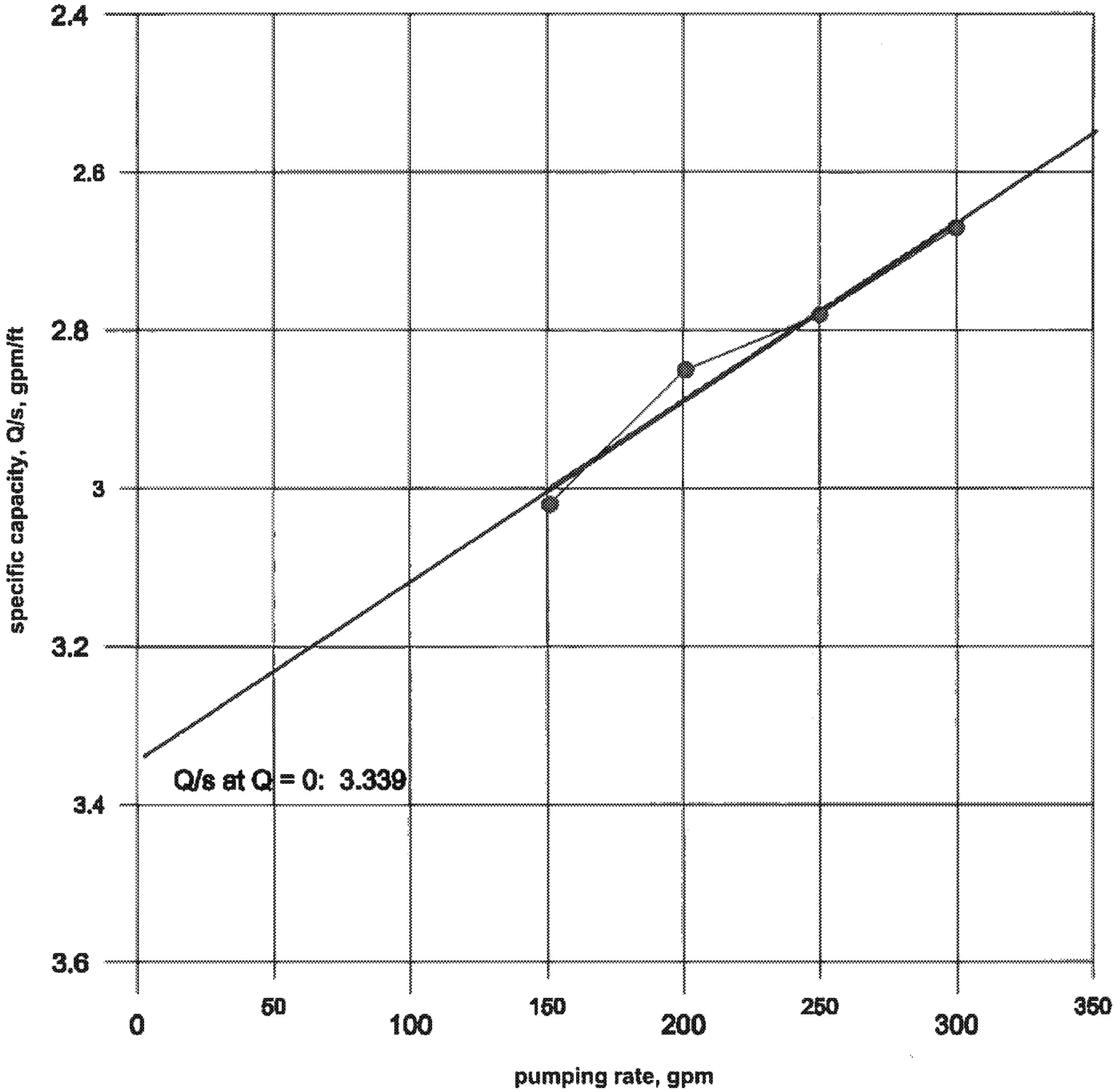

Figure 5. Plot of short-term specific capacity versus pumping rate, HAMP Well No. 2, Hopi Tribe, Arizona.

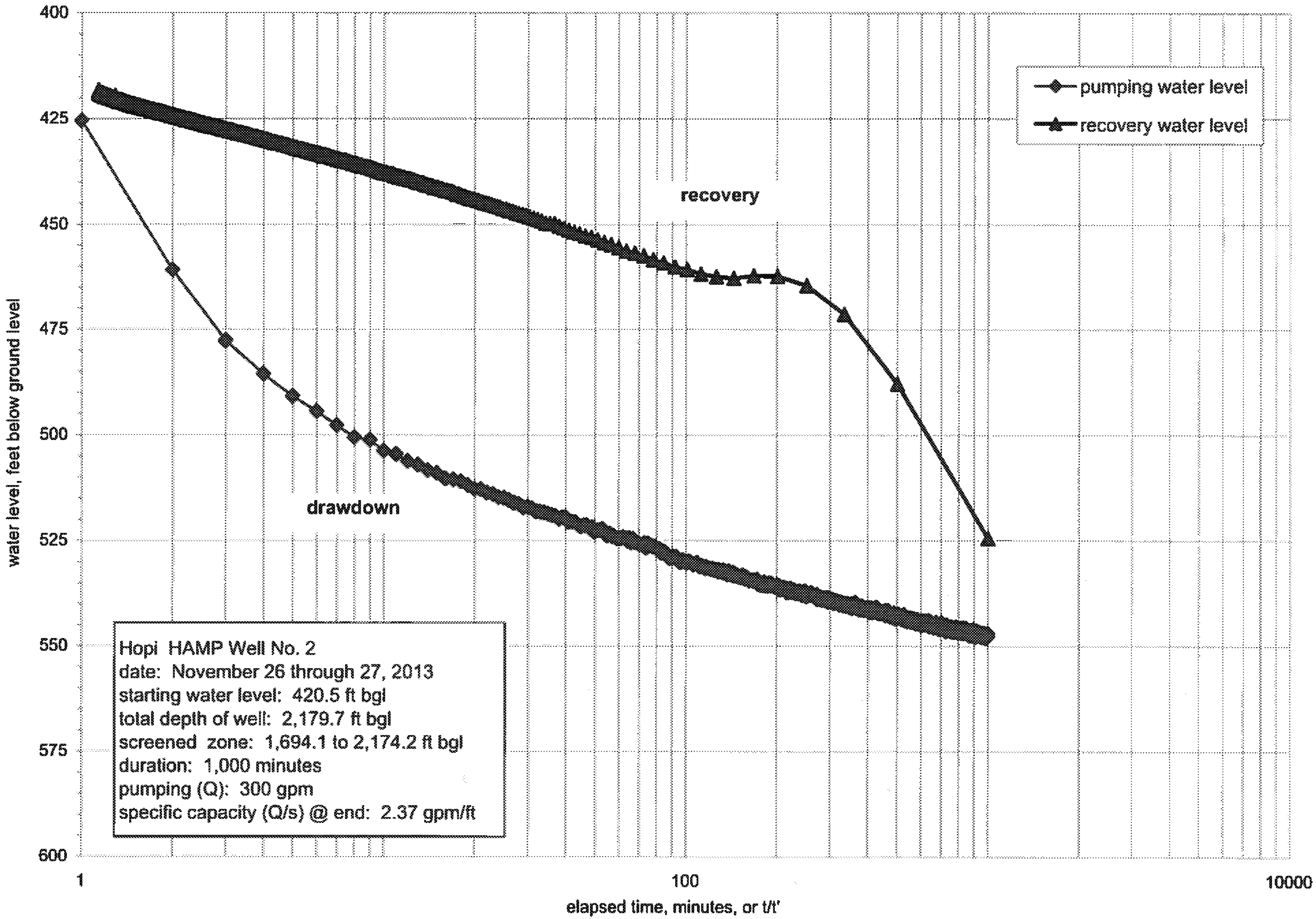

Figure 6. Graph showing results of constant-rate pumping test, HAMP Well No. 2, Hopi Tribe, Arizona.

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Estimates of future pumping water levels given in Table 18 reflect the incremental effects of pumping the well itself at various rates, and an assumed rate of regional water-level change. They are based on the June 18, 2014 non-pumping depth to water of 451.2 ft; a short-term (100-minute) specific capacity, primarily reflecting well losses, based on the interpolated results of the step-drawdown test (Figure 8); the transmissivity estimated from the constant-rate test (564 ft^2/day); a storage coefficient of 4.8×10^{-4} derived from the typical fully confined specific storage value and the thickness of the aquifer open to the well; and no regional drawdown. The estimates, based on the Theis equation, do not account for leakage or variation in N-aquifer properties from place to place. The predicted pumping water level, at a constant rate of 350 gpm, 718 ft, represents about 21 percent of the total available drawdown above the top of the well screen.

A separate report with predicted future pumping water levels, accounting for projected demand and the impacts of regional pumping, is in preparation. Recognizing the uncertainties in the calculations, the pump setting depth should be substantially greater than the predicted pumping water level given in Table 18 for any particular rate.

Table 18. Summary of long-term pumping level estimates, assuming no regional water-level change HAMP Well No. 3, Hopi Tribe, Arizona

pumping rate, constant, gpm	starting water level, ft bgl	100-min specific capacity, gpm/ft	100-min drawdown, ft bgl	5 years			40 years		
				regional drawdown, ft bgl	additional drawdown after 100 min, ft	pumping water level, ft bgl	regional drawdown, ft bgl	additional drawdown after 100 min, ft	pumping water level, ft bgl
175	451	2.63	67	0	49	567	0	58	576
200	451	2.60	77	0	55	583	0	67	595
250	451	2.51	100	0	69	620	0	83	634
300	451	2.43	123	0	83	659	0	100	674
350	451	2.33	150	0	97	698	0	117	718
415	451	2.15	193	0	115	759	0	138	782

ft bgl - feet below ground level
gpm - gallons per minute

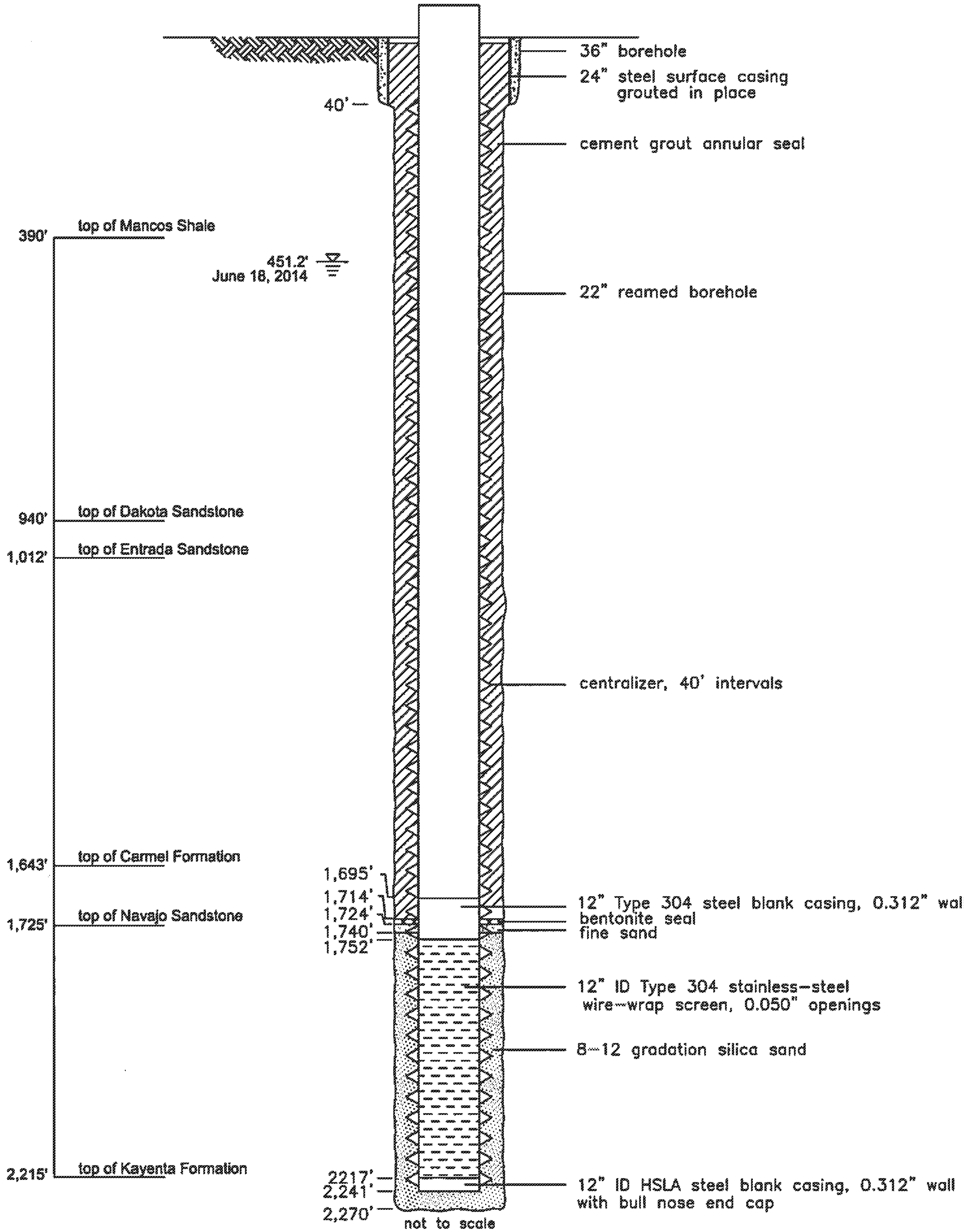

Figure 7. Well completion diagram, HAMP Well No. 3, Hopi Tribe, Arizona.

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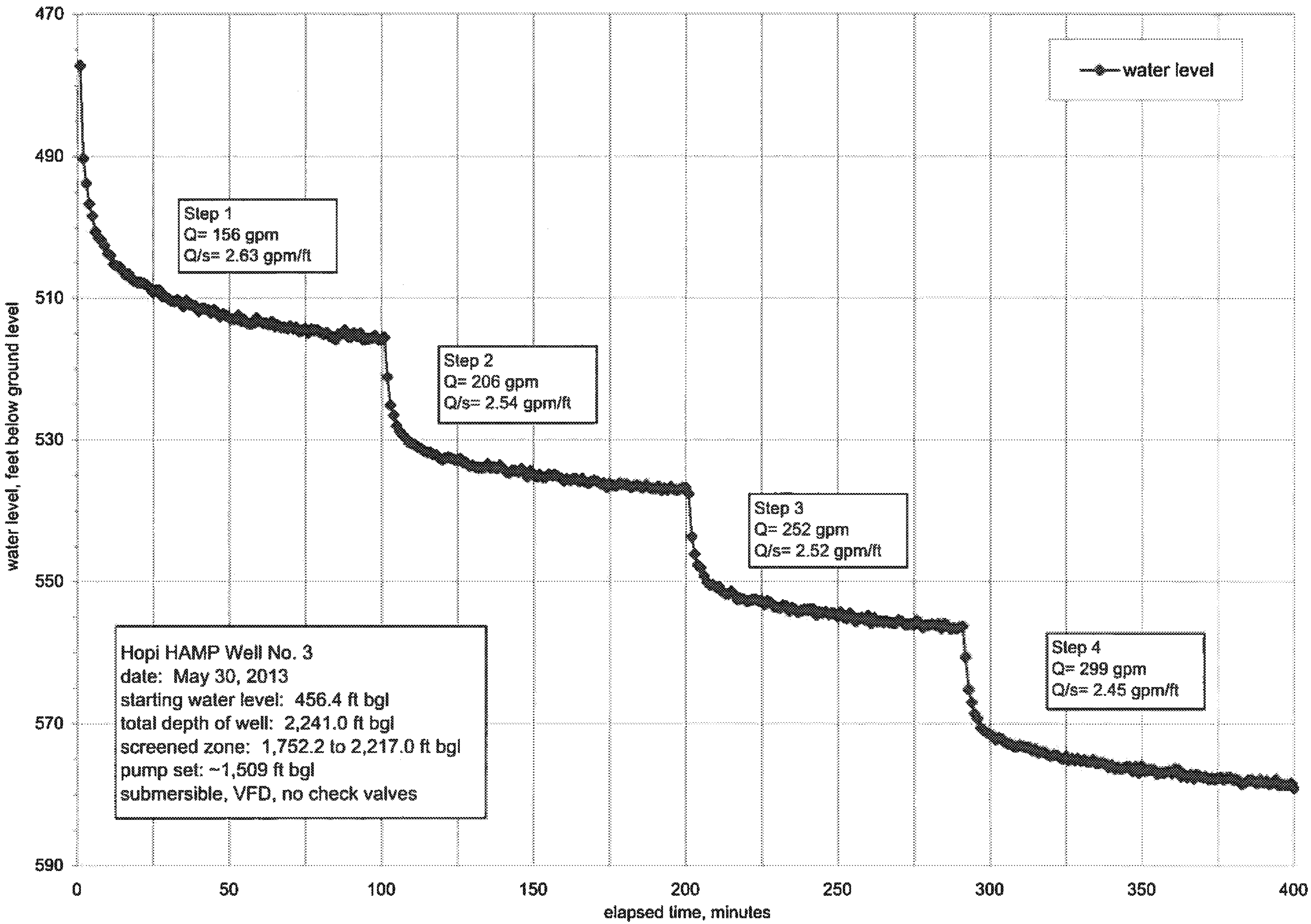

Figure 8. Graph showing results of step-drawdown pumping, HAMP Well No. 3, Hopi Tribe, Arizona.

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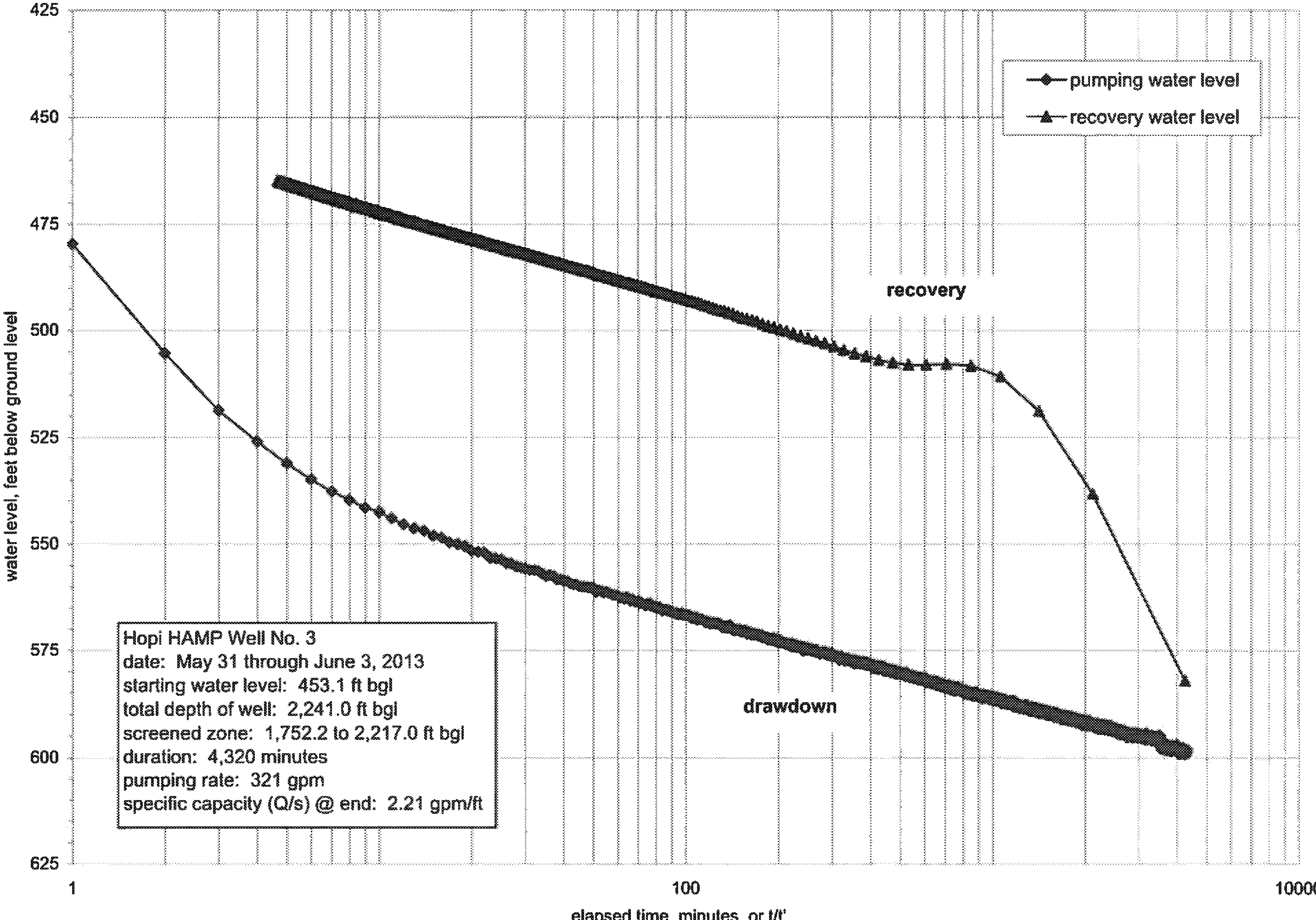
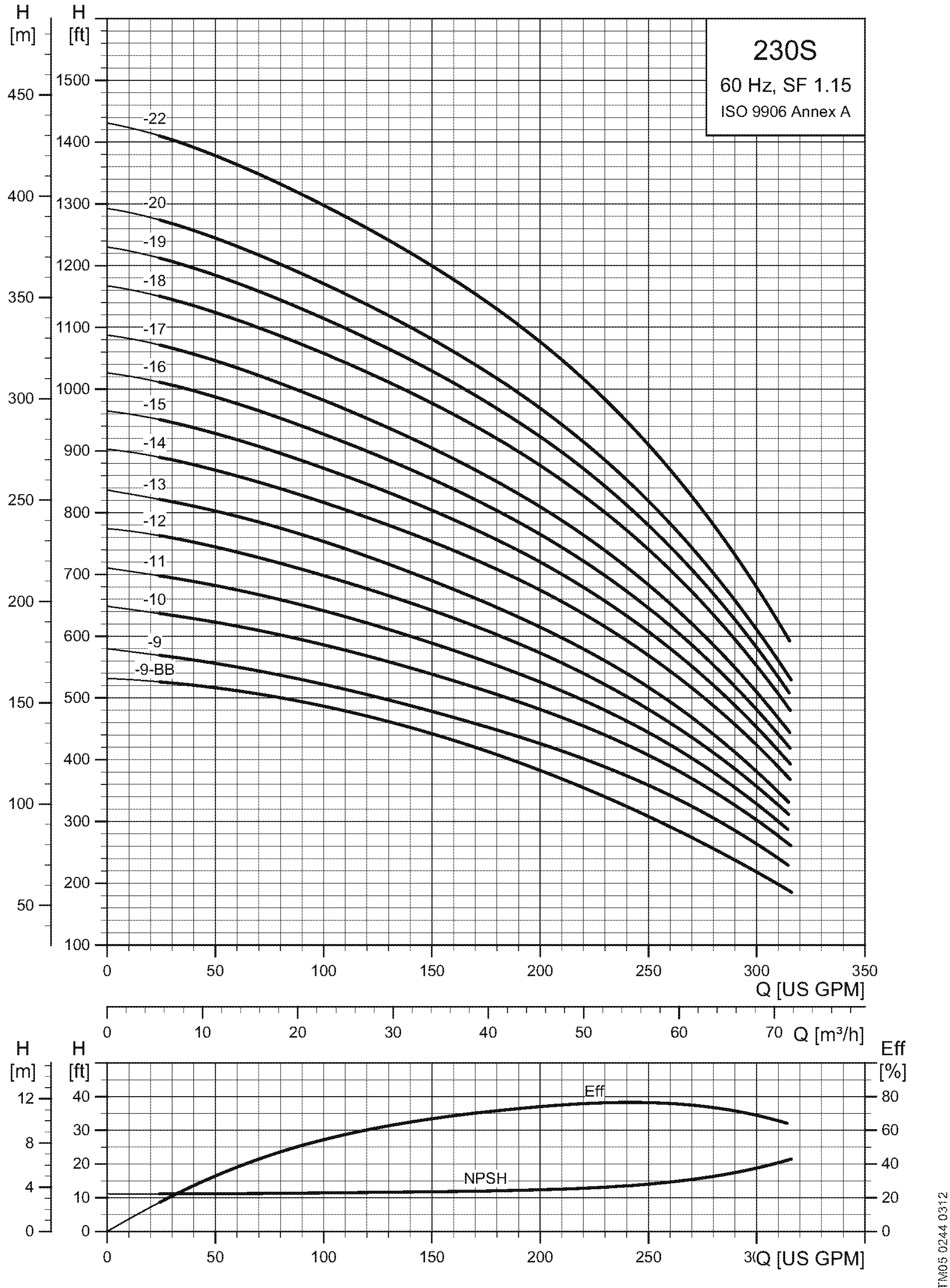


Figure 9. Graph showing results of constant-rate pumping test performed, HAMP Well No. 3, Hopi Tribe, Arizona.

230S (230 gpm)



ED_005149_00040357-00053

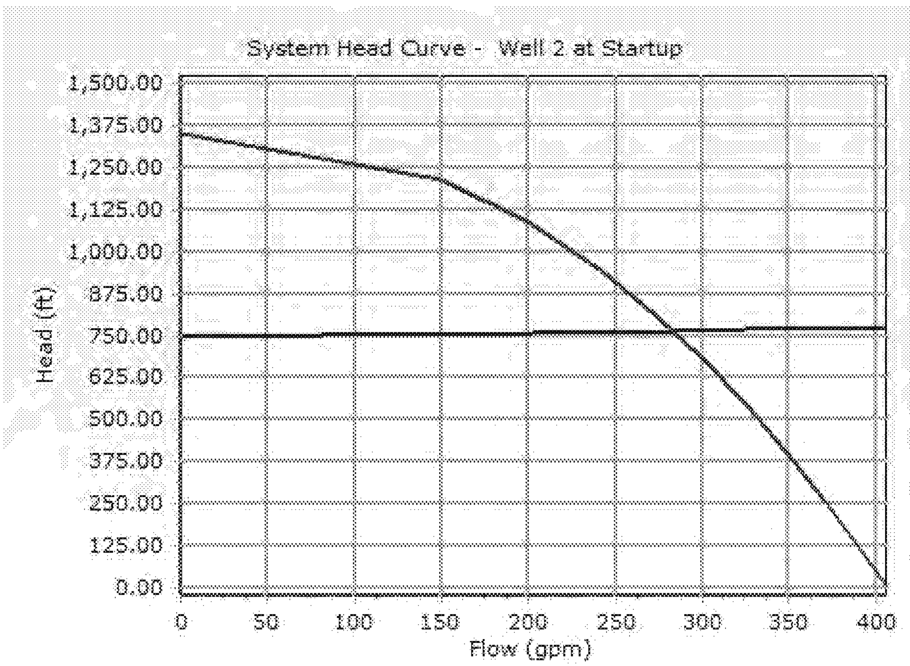
System Head Curve Detailed Report - System Head Curve - 4

Element Details

Label	System Head Curve - 4	Number of Intervals	10
Pump	Pump Well 2	Specify vertical axis limits	False
Maximum Flow	407 gpm		

Time (hours)
0.000

System Head Curve @ 0.000 hours Flow (gpm)	System Head Curve @ 0.000 hours Head (ft)	230S750-22DS Flow (gpm)	230S750-22DS Head (ft)
0	747.58	407	0.00
41	748.52	389	135.24
81	750.18	369	270.48
122	752.19	349	405.72
163	754.54	326	540.96
204	757.21	301	676.20
244	760.37	273	811.44
285	763.99	241	946.68
326	768.03	202	1,081.92
366	772.48	150	1,217.16
407	777.34	0	1,352.40



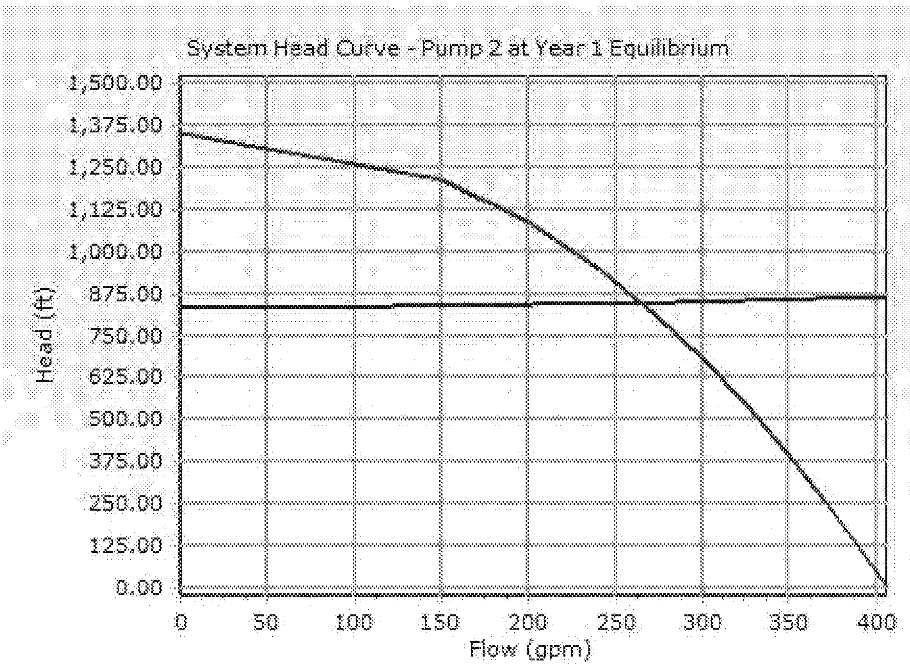
System Head Curve Detailed Report - System Head Curve - 5

Element Details

Label	System Head Curve - 5	Number of Intervals	10
Pump	Pump Well 2	Specify vertical axis limits	False
Maximum Flow	407 gpm		

Time (hours)
0.000

System Head Curve @ 0.000 hours Flow (gpm)	System Head Curve @ 0.000 hours Head (ft)	230S750-22DS Flow (gpm)	230S750-22DS Head (ft)
0	833.03	407	0.00
41	833.85	389	135.24
81	835.49	369	270.48
122	837.55	349	405.72
163	840.00	326	540.96
204	842.83	301	676.20
244	846.18	273	811.44
285	850.05	241	946.68
326	854.39	202	1,081.92
366	859.20	150	1,217.16
407	864.45	0	1,352.40



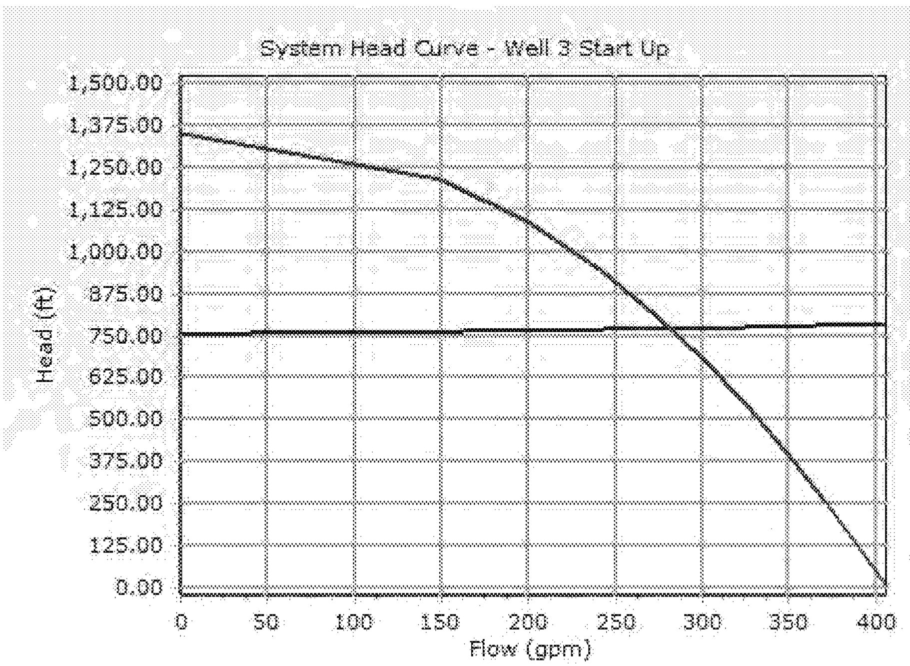
System Head Curve Detailed Report - System Head Curve - 6

Element Details

Label	System Head Curve - 6	Number of Intervals	10
Pump	Pump Well 3	Specify vertical axis limits	False
Maximum Flow	407 gpm		

Time (hours)
0.000

System Head Curve @ 0.000 hours Flow (gpm)	System Head Curve @ 0.000 hours Head (ft)	230S750-22DS Flow (gpm)	230S750-22DS Head (ft)
0	755.63	407	0.00
41	756.26	389	135.24
81	757.77	369	270.48
122	759.73	349	405.72
163	762.15	326	540.96
204	765.00	301	676.20
244	768.28	273	811.44
285	771.98	241	946.68
326	776.07	202	1,081.92
366	780.57	150	1,217.16
407	785.45	0	1,352.40



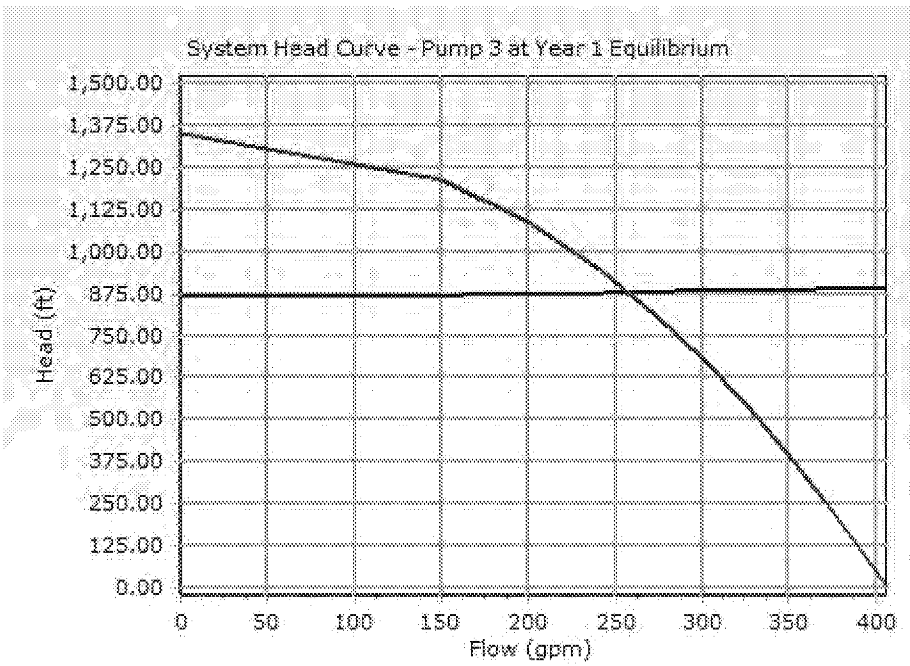
System Head Curve Detailed Report - System Head Curve - 2

Element Details

Label	System Head Curve - 2	Number of Intervals	10
Pump	Pump Well 3	Specify vertical axis limits	False
Maximum Flow	407 gpm		

Time (hours)
0.000

System Head Curve @ 0.000 hours Flow (gpm)	System Head Curve @ 0.000 hours Head (ft)	230S750-22DS Flow (gpm)	230S750-22DS Head (ft)
0	865.67	407	0.00
41	866.22	389	135.24
81	867.65	369	270.48
122	869.54	349	405.72
163	871.89	326	540.96
204	874.67	301	676.20
244	877.88	273	811.44
285	881.50	241	946.68
326	885.54	202	1,081.92
366	889.96	150	1,217.16
407	894.78	0	1,352.40



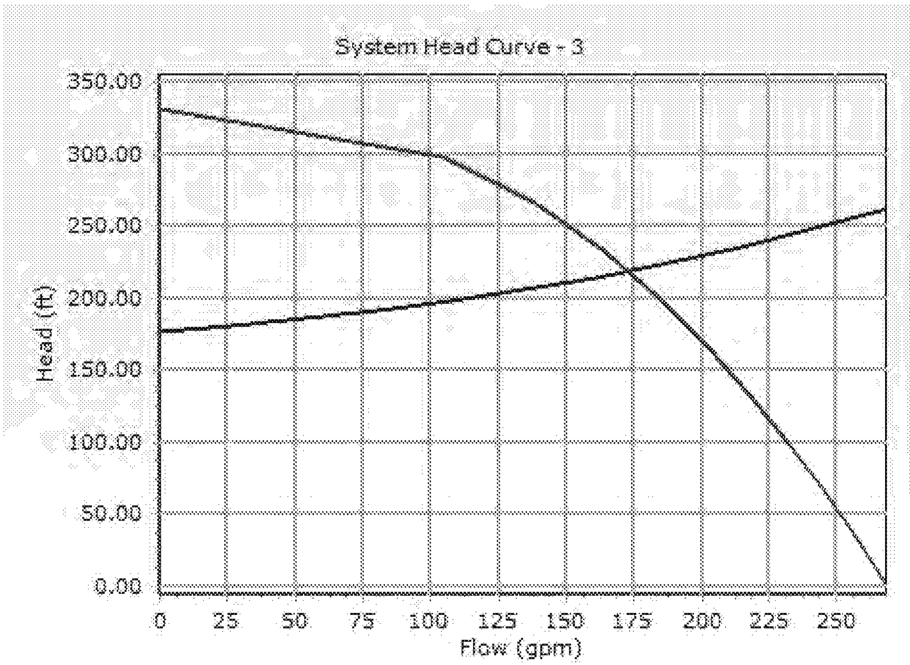
System Head Curve Detailed Report - System Head Curve - 3

Element Details

Label	System Head Curve - 3	Number of Intervals	10
Pump	Hopi Booster 1	Specify vertical axis limits	False
Maximum Flow	269 gpm		

Time (hours)
0.000

System Head Curve @ 0.000 hours Flow (gpm)	System Head Curve @ 0.000 hours Head (ft)	CR32-4-2 Flow (gpm)	CR32-4-2 Head (ft)
0	177.06	269	0.00
27	180.82	258	33.19
54	185.74	245	66.37
81	191.57	232	99.56
108	198.18	218	132.75
134	205.65	202	165.94
161	214.46	185	199.12
188	224.57	164	232.31
215	235.92	139	265.50
242	248.47	104	298.69
269	262.19	0	331.87



FlexTable: Junction Table

Current Time: 0.00 hours

Label	Pressure (Minimum) (psi)	Pressure (Maximum) (psi)	Elevation (ft)
5482	219	239	5,878.43
5485	219	238	5,879.49
5479	218	238	5,882.19
J-160	214	234	5,890.00
5488	213	232	5,893.28
13628	146	225	5,681.68
13627	146	225	5,683.24
15090	144	224	5,685.65
15093	144	223	5,686.96
5491	204	222	5,914.54
15091	142	222	5,688.85
13315	141	222	5,690.11
13292	137	221	5,691.74
J-175	136	221	5,692.00
15097	141	221	5,692.08
13318	139	220	5,695.11
15098	138	218	5,698.79
5494	199	218	5,924.04
13781	143	218	5,699.59
13293	133	217	5,700.48
13570	133	217	5,700.70
13314	135	216	5,702.32
13742	148	215	5,704.73
13745	147	215	5,705.55
13737	148	215	5,706.23
13401	139	214	5,708.32
5497	195	213	5,933.60
13313	131	213	5,709.90
13735	146	212	5,712.10
13748	143	212	5,713.19
15074	137	211	5,714.75
15159	126	211	5,715.15
13311	127	209	5,718.72
13294	125	209	5,719.74
J-88	127	209	5,720.00
5540	190	208	5,945.24
13731	142	208	5,721.47
13137	130	208	5,721.53
13775	135	208	5,721.53
13142	133	208	5,721.67
13139	131	207	5,724.04
13138	130	207	5,724.84
13750	137	206	5,726.04
13296	123	206	5,726.36
13132	127	205	5,728.19
13136	126	204	5,730.11

FlexTable: Junction Table

Current Time: 0.00 hours

Label	Pressure (Minimum) (psi)	Pressure (Maximum) (psi)	Elevation (ft)
13728	139	204	5,730.11
13773	130	203	5,733.56
13755	133	203	5,734.27
5543	184	202	5,959.72
J-90	117	200	5,740.00
5027	145	200	5,740.34
13772	126	199	5,742.81
5546	181	199	5,966.67
5021	140	197	5,747.60
5024	141	197	5,747.85
5035	143	196	5,748.73
5032	142	196	5,749.09
5549	178	196	5,972.44
13771	123	196	5,750.63
5038	142	195	5,751.47
5042	142	194	5,753.48
5016	136	193	5,755.89
13760	122	193	5,756.54
13769	120	192	5,758.69
5063	144	192	5,759.72
5108	152	192	5,759.81
13024	106	191	5,760.10
5066	144	191	5,761.53
5552	173	190	5,985.61
J-81	118	190	5,764.00
5060	141	189	5,764.77
5069	142	189	5,765.81
J-48	138	189	5,766.00
5051	138	188	5,768.86
J-85	123	187	5,770.00
5054	137	187	5,770.50
5048	136	187	5,770.66
5057	138	187	5,770.91
5072	140	186	5,773.03
5555	169	186	5,994.62
5076	140	186	5,773.42
13763	114	185	5,774.29
J-47	140	185	5,776.00
J-49	126	184	5,777.00
5105	144	184	5,777.44
5079	139	183	5,778.63
5082	139	183	5,779.61
5103	142	183	5,780.24
5085	139	183	5,780.54
5012	123	182	5,781.86
5111	143	182	5,782.33

FlexTable: Junction Table

Current Time: 0.00 hours

Label	Pressure (Minimum) (psi)	Pressure (Maximum) (psi)	Elevation (ft)
5094	140	182	5,782.85
5100	140	181	5,783.72
5097	140	181	5,783.84
5088	138	181	5,784.87
5117	142	179	5,787.79
5091	137	179	5,787.94
5558	161	178	6,012.32
J-62	105	177	5,794.00
J-60	113	174	5,801.00
5561	152	168	6,034.23
J-92	82	167	5,816.00
117	129	163	5,825.44
5601	147	163	6,044.03
J-46	128	162	5,829.00
5604	145	160	6,049.81
5565	141	157	6,058.93
5598	140	156	6,060.63
J-95	122	154	5,847.00
5152	122	154	5,847.12
5607	139	153	6,064.51
5155	120	151	5,853.09
5158	120	151	5,854.23
5161	120	151	5,854.26
5167	120	149	5,857.26
5164	119	149	5,858.54
J-141	135	148	5,880.00
J-142	132	145	5,887.00
5170	116	145	5,867.65
J-162	131	144	5,890.00
J-102	130	144	5,892.00
J-153	131	143	5,890.00
J-139	131	143	5,890.00
5173	115	143	5,871.17
J-68	131	143	5,890.18
J-6	129	143	5,895.00
J-101	129	143	5,893.84
13025	56	142	5,875.43
5569	125	141	6,095.58
J-161	127	140	5,900.00
5610	125	140	6,095.90
J-138	126	139	5,901.00
5176	110	138	5,882.87
5595	122	137	6,102.66
J-105	125	136	5,905.00
5185	107	134	5,893.72
J-36	122	133	5,780.00

FlexTable: Junction Table

Current Time: 0.00 hours

Label	Pressure (Minimum) (psi)	Pressure (Maximum) (psi)	Elevation (ft)
5188	104	130	5,900.97
J-35	121	128	5,790.00
J-121	123	127	5,909.00
5572	110	126	6,130.70
J-45	99	124	5,915.00
5613	109	124	6,132.48
5194	96	121	5,923.10
5197	96	121	5,923.42
5592	105	121	6,141.57
13026	35	120	5,924.41
J-31	118	120	6,050.00
5200	95	119	5,926.38
5576	101	117	6,150.90
J-106	107	116	5,947.00
5616	100	115	6,153.61
J-74	90	114	5,939.40
5203	90	114	5,939.42
5580	97	113	6,161.44
5586	95	111	6,164.92
5589	95	111	6,165.26
5583	95	110	6,166.18
J-9	101	110	5,960.00
5620	95	109	6,165.37
5204	84	107	5,955.28
5622	90	104	6,177.52
J-34	100	101	5,850.00
J-33	100	101	5,850.00
5214	78	101	5,970.15
J-114	92	100	5,981.00
J-113	87	99	6,184.00
J-14	83	98	6,192.00
5215	76	98	5,977.03
J-174	9	95	5,983.20
J-29	84	93	6,185.00
J-118	80	92	6,188.00
J-10	83	91	6,000.00
J-172	83	91	6,190.00
5221	67	88	5,998.56
5225	66	87	6,000.81
J-120	85	86	6,128.00
J-171	79	86	6,200.00
J-12	68	83	6,010.00
J-117	76	83	6,017.00
5228	58	79	6,020.00
J-115	70	77	6,030.00
5838	71	76	6,322.07

FlexTable: Junction Table

Current Time: 0.00 hours

Label	Pressure (Minimum) (psi)	Pressure (Maximum) (psi)	Elevation (ft)
J-112	63	76	6,240.00
J-23	65	76	6,235.00
5230	55	75	6,029.44
J-135	68	73	6,328.70
5841	67	72	6,329.30
5861	68	71	6,327.73
5844	67	71	6,331.25
5862	68	71	6,327.63
5849	66	70	6,333.51
J-116	62	69	6,048.00
5870	65	67	6,335.20
5857	63	67	6,338.59
J-107	55	66	6,257.12
J-32	65	65	6,050.00
5881	59	63	6,348.09
J-108	51	61	6,268.00
J-119	60	60	6,188.00
J-176	58	60	5,700.00
J-37	58	60	6,352.00
J-55	57	60	6,352.00
5872	57	59	6,353.69
J-15	45	57	6,280.00
J-22	41	52	6,291.00
1071	41	52	6,288.95
J-59	41	50	6,285.00
J-109	39	49	6,294.95
J-169	38	48	6,297.00
J-165	36	47	6,301.00
2192	34	44	6,304.78
2220	34	43	6,305.35
2625	34	43	6,304.83
J-133	32	42	6,311.07
J-30	32	41	6,305.00
2256	31	41	6,310.75
2152	31	40	6,313.48
2698	30	39	6,313.11
J-131	28	38	6,318.76
2554	29	38	6,316.82
2483	28	37	6,318.46
2338	26	35	6,323.49
J-58	25	35	6,320.00
2350	25	34	6,326.17
J-170	23	33	6,330.00
J-168	23	33	6,331.44
2785	24	32	6,327.37
J-11	25	32	6,130.00

FlexTable: Junction Table

Current Time: 0.00 hours

Label	Pressure (Minimum) (psi)	Pressure (Maximum) (psi)	Elevation (ft)
2047	22	32	6,333.78
J-151	25	31	6,130.00
2917	22	30	6,332.48
2836	21	30	6,333.26
J-111	19	27	6,338.00
2891	19	27	6,338.29
2948	19	27	6,338.45
3072	18	25	6,341.57
3127	15	22	6,347.51
J-27	15	22	6,348.00
J-167	15	22	6,348.10
J-122	11	19	6,357.00
J-53	8	10	5,984.50
J-54	8	10	5,780.00
J-173	(N/A)	(N/A)	5,700.00

FlexTable: Pipe Table

Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-24	12,342	22.91	0.002	10.8	HDPE	140.0	0	2.46	697
P-106	6,131	11.38	0.002	10.8	HDPE	140.0	0	2.46	697
P-42	2,327	10.13	0.004	3.9	HDPE	140.0	0	2.01	75
P-223-1	3,782	8.65	0.002	10.3	HDPE	140.0	0	2.68	697
P-44	1,897	8.25	0.004	3.9	HDPE	140.0	0	2.01	75
P-130	2,773	8.08	0.003	9.8	HDPE	140.0	0	2.96	697
P-40	1,480	6.44	0.004	3.9	HDPE	140.0	0	2.01	75
P-9	4	5.82	0.008	6.0	GI	120.0	700	3.23	285
P-193	3	5.81	0.008	6.0	GI	120.0	700	3.23	284
P-37-1	1,117	3.82	0.005	3.9	HDPE	140.0	0	2.24	83
P-57-2	2,059	3.82	0.002	10.8	HDPE	140.0	0	2.46	697
P-82-1	1,217	3.54	0.003	9.8	HDPE	140.0	0	2.96	697
P-132	1,074	3.13	0.003	9.8	HDPE	140.0	0	2.96	697
P-37-4	635	2.76	0.004	3.9	HDPE	140.0	0	2.01	75
P-223	1,151	2.63	0.002	10.3	HDPE	140.0	0	2.68	697
P-82	859	2.50	0.003	9.8	HDPE	140.0	0	2.96	697
P-311	857	2.50	0.003	9.8	HDPE	140.0	0	2.96	697
P-294	1,070	2.45	0.002	10.3	HDPE	140.0	0	2.68	697
P-330	1,589	2.42	0.002	11.2	PVC	140.0	0	2.27	697
P-30	8,656	2.39	0.000	9.4	HDPE	140.0	0	0.83	180
P-62-4	813	2.37	0.003	9.8	HDPE	140.0	0	2.96	697
P-94-1	4,094	2.36	0.001	11.1	HDPE	140.0	0	1.87	565
P-64-2	797	2.32	0.003	9.8	HDPE	140.0	0	2.96	697
P-60-5	791	2.31	0.003	9.8	HDPE	140.0	0	2.96	697
P-295	753	2.19	0.003	9.8	HDPE	140.0	0	2.96	697
P-26	7,688	2.13	0.000	9.4	HDPE	140.0	0	0.83	180
P-223-3	709	2.06	0.003	9.8	HDPE	140.0	0	2.96	697
P-150	2,631	2.03	0.001	7.6	HDPE	140.0	0	1.24	176
P-37-5	464	2.02	0.004	3.9	HDPE	140.0	0	2.01	75
P-314	668	1.95	0.003	9.8	HDPE	140.0	0	2.96	697

FlexTable: Pipe Table

Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-40-2	416	1.81	0.004	3.9	HDPE	140.0	0	2.01	75
P-60-3	602	1.76	0.003	9.8	HDPE	140.0	0	2.96	697
P-313	587	1.71	0.003	9.8	HDPE	140.0	0	2.96	697
P-62-2	586	1.71	0.003	9.8	HDPE	140.0	0	2.96	697
P-22	2,941	1.70	0.001	11.1	HDPE	140.0	0	1.87	565
P-28	6,129	1.70	0.000	9.4	HDPE	140.0	0	0.83	180
P-32	6,045	1.67	0.000	9.4	HDPE	140.0	0	0.83	180
P-59-3	562	1.64	0.003	9.8	HDPE	140.0	0	2.96	697
P-299	560	1.63	0.003	9.8	HDPE	140.0	0	2.96	697
P-136	558	1.63	0.003	9.8	HDPE	140.0	0	2.96	697
P-300	552	1.61	0.003	9.8	HDPE	140.0	0	2.96	697
P-62-3	548	1.60	0.003	9.8	HDPE	140.0	0	2.96	697
P-35-3(2)	3,178	1.60	0.001	5.8	hdpe	140.0	0	1.15	95
P-347	182	1.59	0.009	5.6	HDPE	140.0	0	3.70	284
P-57	851	1.58	0.002	10.8	HDPE	140.0	0	2.46	697
P-59-1	538	1.57	0.003	9.8	HDPE	140.0	0	2.96	697
P-62-1	537	1.56	0.003	9.8	HDPE	140.0	0	2.96	697
P-59-5	536	1.56	0.003	9.8	HDPE	140.0	0	2.96	697
P-223-4	526	1.53	0.003	9.8	HDPE	140.0	0	2.96	697
P-64	526	1.53	0.003	9.8	HDPE	140.0	0	2.96	697
P-59-2	525	1.53	0.003	9.8	HDPE	140.0	0	2.96	697
P-59-4	525	1.53	0.003	9.8	HDPE	140.0	0	2.96	697
P-60-4	514	1.50	0.003	9.8	HDPE	140.0	0	2.96	697
P-326	979	1.49	0.002	11.2	PVC	140.0	0	2.27	697
P-62	505	1.47	0.003	9.8	HDPE	140.0	0	2.96	697
P-59-6	504	1.47	0.003	9.8	HDPE	140.0	0	2.96	697
P-315	495	1.44	0.003	9.8	HDPE	140.0	0	2.96	697
P-60-1	488	1.42	0.003	9.8	HDPE	140.0	0	2.96	697
P-58-4	611	1.40	0.002	10.3	HDPE	140.0	0	2.68	697
P-223-2	609	1.39	0.002	10.3	HDPE	140.0	0	2.68	697

FlexTable: Pipe Table

Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-46-4	971	1.38	0.001	5.8	HDPE	140.0	0	1.42	117
P-224-4	602	1.38	0.002	10.3	HDPE	140.0	0	2.68	697
P-118	733	1.36	0.002	10.8	HDPE	140.0	0	2.46	697
P-312	461	1.34	0.003	9.8	HDPE	140.0	0	2.96	697
P-120	718	1.33	0.002	10.8	HDPE	140.0	0	2.46	697
P-116	707	1.31	0.002	10.8	HDPE	140.0	0	2.46	697
P-57-5	570	1.30	0.002	10.3	HDPE	140.0	0	2.68	697
P-94	2,213	1.28	0.001	11.1	HDPE	140.0	0	1.87	565
P-224-2	558	1.27	0.002	10.3	HDPE	140.0	0	2.68	697
P-59	436	1.27	0.003	9.8	HDPE	140.0	0	2.96	697
P-296	430	1.25	0.003	9.8	HDPE	140.0	0	2.96	697
P-224	547	1.25	0.002	10.3	HDPE	140.0	0	2.68	697
P-329	821	1.25	0.002	11.2	PVC	140.0	0	2.27	697
P-223-5	545	1.25	0.002	10.3	HDPE	140.0	0	2.68	697
P-297	427	1.24	0.003	9.8	HDPE	140.0	0	2.96	697
P-338	816	1.24	0.002	11.2	PVC	140.0	0	2.27	697
P-309	424	1.24	0.003	9.8	HDPE	140.0	0	2.96	697
P-57-4	662	1.23	0.002	10.8	HDPE	140.0	0	2.46	697
P-301	421	1.23	0.003	9.8	HDPE	140.0	0	2.96	697
P-12	2,101	1.21	0.001	11.1	HDPE	140.0	0	1.87	565
P-58-2	529	1.21	0.002	10.3	HDPE	140.0	0	2.68	697
P-317	794	1.21	0.002	11.2	PVC	140.0	0	2.27	697
P-213	549	1.17	0.002	10.8	HDPE	130.0	0	2.46	697
P-224-1	505	1.16	0.002	10.3	HDPE	140.0	0	2.68	697
P-224-3	504	1.15	0.002	10.3	HDPE	140.0	0	2.68	697
P-348	2,993	1.14	0.000	7.6	HDPE	140.0	0	0.82	117
P-114	613	1.14	0.002	10.8	HDPE	140.0	0	2.46	697
P-224-6	495	1.13	0.002	10.3	HDPE	140.0	0	2.68	697
P-223-6	495	1.13	0.002	10.3	HDPE	140.0	0	2.68	697
P-57-3	609	1.13	0.002	10.8	HDPE	140.0	0	2.46	697

FlexTable: Pipe Table

Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-337	1,218	1.13	0.003	9.8	HDPE	140.0	0	2.85	670
P-58-1	491	1.12	0.002	10.3	HDPE	140.0	0	2.68	697
P-221-2	523	1.11	0.002	10.8	HDPE	130.0	0	2.46	697
P-48	778	1.11	0.001	5.8	HDPE	140.0	0	1.42	117
P-221-4	592	1.10	0.002	10.8	HDPE	140.0	0	2.46	697
P-112	585	1.09	0.002	10.8	HDPE	140.0	0	2.46	697
P-308	368	1.07	0.003	9.8	HDPE	140.0	0	2.96	697
P-224-5	467	1.07	0.002	10.3	HDPE	140.0	0	2.68	697
P-57-1	566	1.05	0.002	10.8	HDPE	140.0	0	2.46	697
P-134	360	1.05	0.003	9.8	HDPE	140.0	0	2.96	697
P-46-5	728	1.04	0.001	5.8	HDPE	140.0	0	1.42	117
P-48-1	715	1.02	0.001	5.8	HDPE	140.0	0	1.42	117
P-302	342	1.00	0.003	9.8	HDPE	140.0	0	2.96	697
P-221-3	535	0.99	0.002	10.8	HDPE	140.0	0	2.46	697
P-110	534	0.99	0.002	10.8	HDPE	140.0	0	2.46	697
P-298	339	0.99	0.003	9.8	HDPE	140.0	0	2.96	697
P-319	625	0.95	0.002	11.2	PVC	140.0	0	2.27	697
P-64-1	324	0.94	0.003	9.8	HDPE	140.0	0	2.96	697
P-48-3	658	0.94	0.001	5.8	HDPE	140.0	0	1.42	117
P-46-3	645	0.92	0.001	5.8	HDPE	140.0	0	1.42	117
P-138	315	0.92	0.003	9.8	HDPE	140.0	0	2.96	697
P-20	1,586	0.92	0.001	11.1	HDPE	140.0	0	1.87	565
P-333	587	0.89	0.002	11.2	PVC	140.0	0	2.27	697
P-57-6	378	0.86	0.002	10.3	HDPE	140.0	0	2.68	697
P-303(2)	292	0.85	0.003	9.8	HDPE	140.0	0	2.96	697
P-355	349	0.84	0.002	7.6	HDPE	140.0	0	2.23	315
P-334	545	0.83	0.002	11.2	PVC	140.0	0	2.27	697
P-262	1,131	0.83	0.001	7.7	HDPE	140.0	0	1.24	180
P-122	431	0.80	0.002	10.8	HDPE	140.0	0	2.46	697
P-50	560	0.80	0.001	5.8	HDPE	140.0	0	1.42	117

FlexTable: Pipe Table

Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-35-3(1)	1,567	0.79	0.001	5.8	hdpe	140.0	0	1.23	101
P-259	1,076	0.79	0.001	7.7	HDPE	140.0	0	1.24	180
P-257	1,069	0.78	0.001	7.7	HDPE	140.0	0	1.24	180
P-261	1,058	0.77	0.001	7.7	HDPE	140.0	0	1.24	180
P-260	1,051	0.77	0.001	7.7	HDPE	140.0	0	1.24	180
P-108	411	0.76	0.002	10.8	HDPE	140.0	0	2.46	697
P-345	1,061	0.74	0.001	9.4	HDPE	140.0	0	1.32	285
P-304	253	0.74	0.003	9.8	HDPE	140.0	0	2.96	697
P-98	1,030	0.72	0.001	9.4	HDPE	140.0	0	1.32	285
P-258	984	0.72	0.001	7.7	HDPE	140.0	0	1.24	180
P-320	445	0.68	0.002	11.2	PVC	140.0	0	2.27	697
P-307	231	0.67	0.003	9.8	HDPE	140.0	0	2.96	697
P-14	1,140	0.66	0.001	11.1	HDPE	140.0	0	1.87	565
P-58-5	281	0.64	0.002	10.3	HDPE	140.0	0	2.68	697
P-256	878	0.64	0.001	7.7	HDPE	140.0	0	1.24	180
P-50-1	446	0.64	0.001	5.8	HDPE	140.0	0	1.42	117
P-310	218	0.63	0.003	9.8	HDPE	140.0	0	2.96	697
P-94-2	1,058	0.61	0.001	11.1	HDPE	140.0	0	1.87	565
P-322	401	0.61	0.002	11.2	PVC	140.0	0	2.27	697
P-18	1,029	0.59	0.001	11.1	HDPE	140.0	0	1.87	565
P-340	642	0.59	0.003	9.8	HDPE	140.0	0	2.85	670
P-96	837	0.59	0.001	9.4	HDPE	140.0	0	1.32	285
P-316	198	0.58	0.003	9.8	HDPE	140.0	0	2.96	697
P-58-3	253	0.58	0.002	10.3	HDPE	140.0	0	2.68	697
P-303(1)	195	0.57	0.003	9.8	HDPE	140.0	0	2.96	697
P-50-2	370	0.53	0.001	5.8	HDPE	140.0	0	1.42	117
P-144	1,842	0.51	0.000	9.4	HDPE	140.0	0	0.83	180
P-265	1,113	0.50	0.000	8.5	HDPE	140.0	0	1.02	180
P-267	1,099	0.50	0.000	8.5	HDPE	140.0	0	1.02	180
P-263	1,074	0.48	0.000	8.5	HDPE	140.0	0	1.02	180

FlexTable: Pipe Table

Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-266	1,067	0.48	0.000	8.5	HDPE	140.0	0	1.02	180
P-270	1,061	0.48	0.000	8.5	HDPE	140.0	0	1.02	180
P-332	299	0.46	0.002	11.2	PVC	140.0	0	2.27	697
P-268	1,008	0.46	0.000	8.5	HDPE	140.0	0	1.02	180
P-269	965	0.44	0.000	8.5	HDPE	140.0	0	1.02	180
P-264	959	0.43	0.000	8.5	HDPE	140.0	0	1.02	180
P-221-1	222	0.41	0.002	10.8	HDPE	140.0	0	2.46	697
P-323	259	0.39	0.002	11.2	PVC	140.0	0	2.27	697
P-272	1,100	0.38	0.000	9.0	HDPE	140.0	0	0.91	180
P-34	1,343	0.37	0.000	9.4	HDPE	140.0	0	0.83	180
P-353	507	0.37	0.002	10.3	HDPE	140.0	0	2.58	670
P-212	552	0.37	0.001	11.1	HDPE	130.0	0	1.87	565
P-271	1,070	0.37	0.000	9.0	HDPE	140.0	0	0.91	180
P-273	1,047	0.36	0.000	9.0	HDPE	140.0	0	0.91	180
P-239	39	0.34	0.009	5.6	HDPE	140.0	0	3.70	284
P-290	1,214	0.34	0.000	9.4	HDPE	140.0	0	0.83	180
P-342	459	0.33	0.002	10.3	HDPE	140.0	0	2.58	670
P-321	218	0.33	0.002	11.2	PVC	140.0	0	2.27	697
P-60-2	114	0.33	0.003	9.8	HDPE	140.0	0	2.96	697
P-306	113	0.33	0.003	9.8	HDPE	140.0	0	2.96	697
P-305	110	0.32	0.003	9.8	HDPE	140.0	0	2.96	697
P-278	1,125	0.31	0.000	9.4	HDPE	140.0	0	0.83	180
P-286	1,112	0.31	0.000	9.4	HDPE	140.0	0	0.83	180
P-277	1,104	0.31	0.000	9.4	HDPE	140.0	0	0.83	180
P-162	388	0.30	0.001	7.6	HDPE	140.0	0	1.24	176
P-281	1,079	0.30	0.000	9.4	HDPE	140.0	0	0.83	180
P-158	386	0.30	0.001	7.6	HDPE	140.0	0	1.24	176
P-283	1,079	0.30	0.000	9.4	HDPE	140.0	0	0.83	180
P-156	385	0.30	0.001	7.6	HDPE	140.0	0	1.24	176
P-282	1,069	0.30	0.000	9.4	HDPE	140.0	0	0.83	180

FlexTable: Pipe Table

Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-276	1,067	0.29	0.000	9.4	HDPE	140.0	0	0.83	180
P-16	507	0.29	0.001	11.1	HDPE	140.0	0	1.87	565
P-287	1,058	0.29	0.000	9.4	HDPE	140.0	0	0.83	180
P-289	1,054	0.29	0.000	9.4	HDPE	140.0	0	0.83	180
P-288	1,049	0.29	0.000	9.4	HDPE	140.0	0	0.83	180
P-284	1,047	0.29	0.000	9.4	HDPE	140.0	0	0.83	180
P-279	1,041	0.29	0.000	9.4	HDPE	140.0	0	0.83	180
P-341	395	0.29	0.002	10.3	HDPE	140.0	0	2.58	670
P-48-2	199	0.28	0.001	5.8	HDPE	140.0	0	1.42	117
P-285	1,012	0.28	0.000	9.4	HDPE	140.0	0	0.83	180
P-339	182	0.28	0.002	11.2	PVC	140.0	0	2.27	697
P-280	996	0.28	0.000	9.4	HDPE	140.0	0	0.83	180
P-327	176	0.27	0.002	11.2	PVC	140.0	0	2.27	697
P-350	183	0.26	0.001	5.8	HDPE	140.0	0	1.42	117
P-224-7	89	0.26	0.003	9.8	HDPE	140.0	0	2.96	697
P-336	260	0.24	0.003	9.8	HDPE	140.0	0	2.85	670
P-160	299	0.23	0.001	7.6	HDPE	140.0	0	1.24	176
P-10	26	0.22	0.008	6.0	GI	120.0	0	3.23	285
P-328	140	0.21	0.002	11.2	PVC	140.0	0	2.27	697
P-178	760	0.21	0.000	9.4	HDPE	140.0	0	0.83	180
P-250	412	0.21	0.001	5.8	HDPE	140.0	0	1.23	101
P-331	132	0.20	0.002	11.2	PVC	140.0	0	2.27	697
P-318	126	0.19	0.002	11.2	PVC	140.0	0	2.27	697
P-70	31	0.19	0.002	5.6	hdpe	140.0	113	1.52	117
P-154	228	0.18	0.001	7.6	HDPE	140.0	0	1.24	176
P-274	600	0.17	0.000	9.4	HDPE	140.0	0	0.83	180
P-179	33	0.14	0.004	3.9	HDPE	140.0	0	2.01	75
P-356(1)	54	0.13	0.002	7.6	HDPE	140.0	0	2.23	315
P-275	425	0.12	0.000	9.4	HDPE	140.0	0	0.83	180
P-235	892	0.11	0.001	9.4	HDPE	140.0	0	1.31	282

FlexTable: Pipe Table

Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-234	885	0.11	0.001	9.4	HDPE	140.0	0	1.31	282
P-35	396	0.11	0.000	9.4	HDPE	140.0	0	0.83	180
P-152	139	0.11	0.001	7.6	HDPE	140.0	0	1.24	176
P-246	137	0.11	0.001	7.6	HDPE	140.0	0	1.24	176
P-174-2	1,120	0.10	0.001	7.6	HDPE	140.0	0	1.21	132
P-40-1	22	0.09	0.004	3.9	HDPE	140.0	0	2.01	75
P-168	978	0.09	0.001	7.6	HDPE	140.0	0	1.21	171
P-170-3	864	0.08	0.001	7.6	HDPE	140.0	0	1.21	171
P-50-3	43	0.07	0.002	5.6	HDPE	140.0	0	1.52	117
P-37-3	17	0.07	0.004	3.9	HDPE	140.0	0	2.01	75
P-170-2	783	0.07	0.001	7.6	HDPE	140.0	0	1.21	171
P-170-1	777	0.07	0.001	7.6	HDPE	140.0	0	1.21	171
P-356(2)(1)	28	0.07	0.002	7.6	HDPE	140.0	0	2.23	315
P-202	499	0.06	0.001	9.4	HDPE	140.0	0	1.31	174
P-170	675	0.06	0.001	7.6	HDPE	140.0	0	1.21	171
P-230	84	0.06	0.001	7.7	HDPE	140.0	0	1.24	180
P-55-1	14	0.06	0.004	3.9	HDPE	140.0	0	2.01	75
P-67	14	0.06	0.004	3.9	HDPE	140.0	0	2.01	75
P-253	73	0.06	0.001	7.6	HDPE	140.0	0	1.24	21
P-37-2	16	0.05	0.005	3.9	HDPE	140.0	0	2.24	83
P-172-1	580	0.05	0.001	7.6	HDPE	140.0	0	1.21	171
P-174-1	541	0.05	0.001	7.6	HDPE	140.0	0	1.21	132
P-164	542	0.05	0.001	7.6	HDPE	140.0	0	1.21	171
P-335(2)	97	0.05	0.001	11.2	PVC	140.0	0	2.18	670
P-39	10	0.04	0.004	3.9	HDPE	140.0	0	2.01	75
P-38	10	0.04	0.004	3.9	HDPE	140.0	0	2.01	75
P-356(2)(2)	17	0.04	0.002	7.6	HDPE	140.0	0	2.23	315
P-172-2	448	0.04	0.001	7.6	HDPE	140.0	0	1.21	171
P-252	416	0.04	0.001	7.6	HDPE	140.0	0	1.21	171
P-349	86	0.03	0.000	7.6	HDPE	140.0	0	0.82	117

FlexTable: Pipe Table

Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-174-3	342	0.03	0.001	7.6	HDPE	140.0	0	1.21	132
P-174	311	0.03	0.001	7.6	HDPE	140.0	0	1.21	132
P-172-3	256	0.02	0.001	7.6	HDPE	140.0	0	1.21	171
P-335(1)	41	0.02	0.001	11.2	PVC	140.0	0	2.18	670
P-55	3	0.01	0.004	3.9	HDPE	140.0	0	2.01	75
P-346	107	0.01	0.001	9.4	HDPE	140.0	0	1.31	282
P-176	143	0.01	0.001	7.6	HDPE	140.0	0	1.21	132
P-166	135	0.01	0.001	7.6	HDPE	140.0	0	1.21	171
P-219	13	0.01	0.001	11.1	HDPE	130.0	0	1.87	565
P-229	23	0.01	0.000	9.4	HDPE	140.0	0	0.83	180
P-142	10	0.01	0.002	10.8	HDPE	140.0	0	2.37	670
P-354	3	0.00	0.002	10.3	HDPE	140.0	0	2.58	670
P-69	17	0.00	0.001	6.0	Steel	140.0	113	1.44	127
Cult Center Lin	831	0.00	0.000	6.0	Ductile Iron	130.0	0	0.24	21
P-220	1	0.00	0.001	11.1	HDPE	140.0	0	1.87	565
P-6	29	0.00	0.000	99.0	PVC	150.0	1	0.01	284
P-8	29	0.00	0.000	99.0	PVC	150.0	1	0.01	285
P-36	782	0.00	0.000	2.0	Steel	140.0	0	0.09	1
P-66	35	0.00	0.001	12.0	HDPE	140.0	0	1.52	538
P-68	19	0.00	0.001	6.0	PVC	140.0	0	0.90	79
P-80	122	0.00	0.000	2.0	Steel	140.0	0	0.09	1
P-81	1,202	0.00	0.000	2.0	Steel	140.0	0	0.09	1
P-124	405	0.00	0.000	10.3	hdpe	150.0	0	0.00	0
P-128	148	0.00	0.000	9.8	HDPE	140.0	0	0.00	0
P-188	1,497	0.00	0.000	2.0	PVC	130.0	0	0.00	0
Cult Center	236	0.00	0.000	6.0	HDPE	140.0	0	0.24	21
P-351	200	0.00	0.000	7.6	HDPE	140.0	1	0.14	20
P-126(1)	37	0.00	0.000	10.3	hdpe	140.0	0	0.00	0
P-126(2)	55	0.00	0.000	10.3	hdpe	140.0	0	0.00	0

FlexTable: Pipe Table

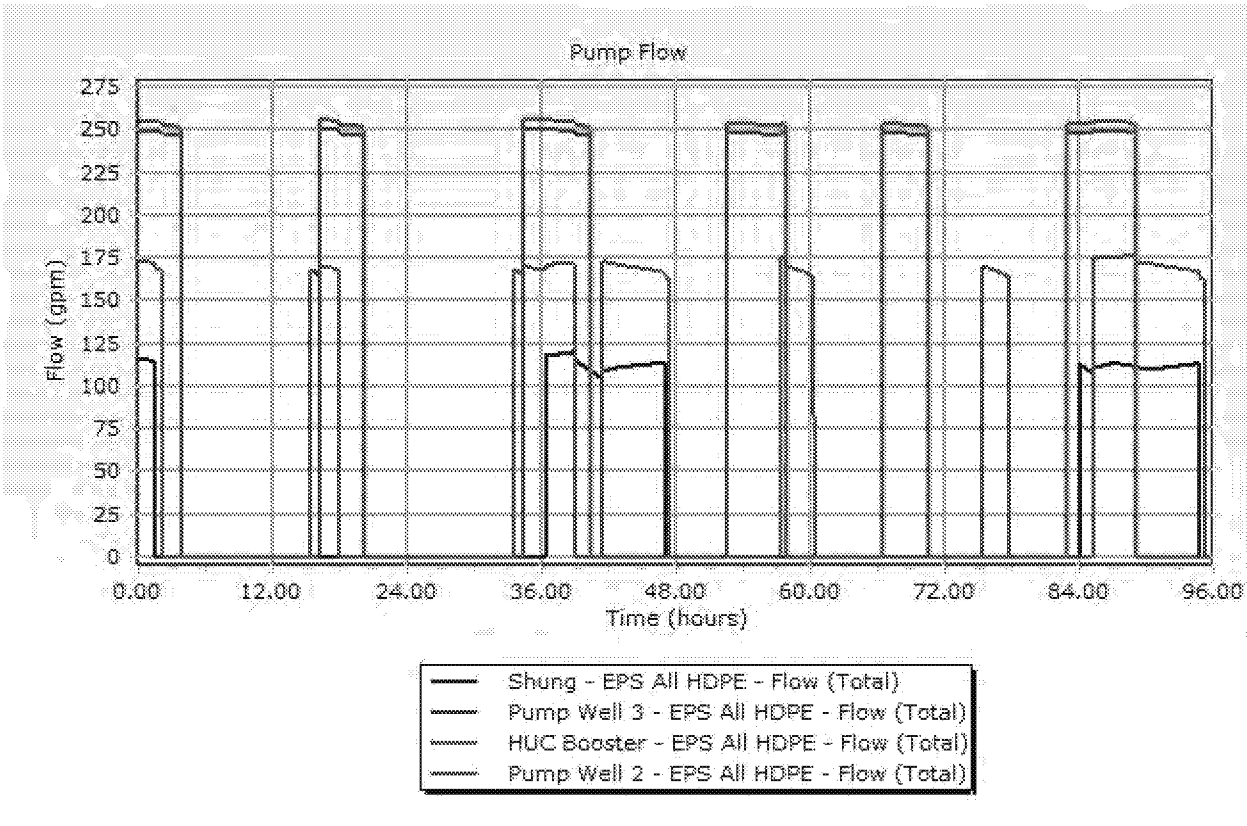
Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-357	17	0.00	0.002	7.6	HDPE	140.0	0	1.93	273
P-352	70	(N/A)	(N/A)	7.6	HDPE	140.0	0	(N/A)	(N/A)

Alternative A Hopi Arsenic Mitigation Project

Hydraulic Model Properties	
Title	HAMP Water Model
Engineer	James P. Carter, PE
Company	Indian Health Service
Date	6/2/2018
Notes	

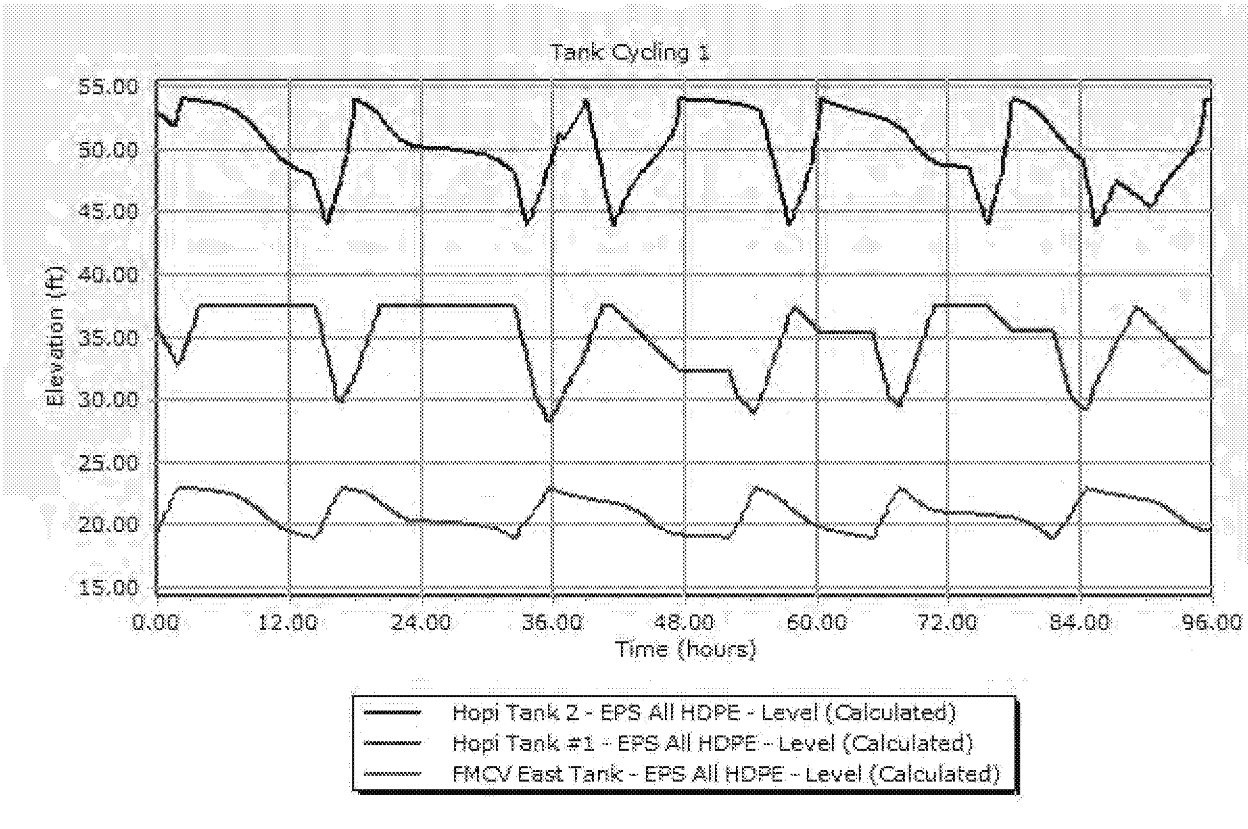
2017 Cycling and Energy Cost



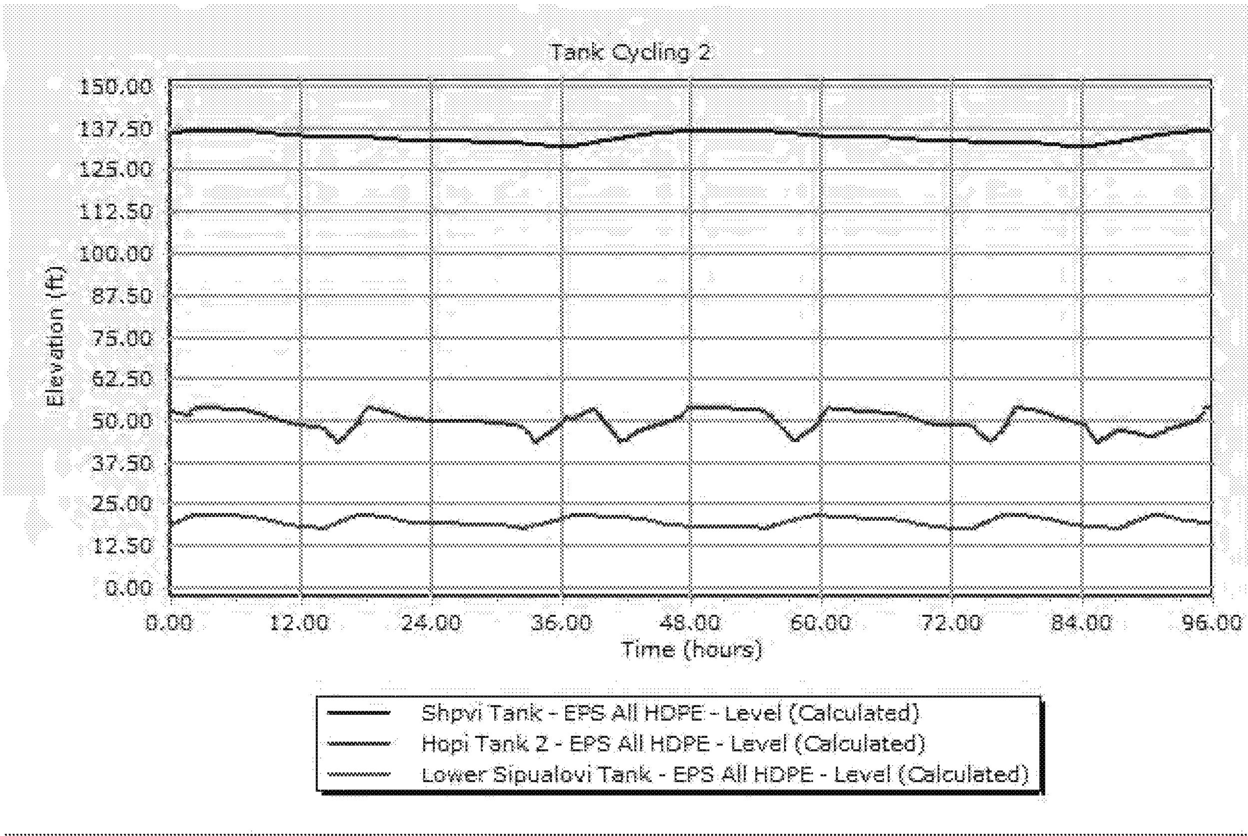
Pump Table - Time: 0.00 hours

Label	Elevation (ft)	Pump Definition	Hydraulic Grade (Suction) (ft)	Flow (Total) (gpm)	Pump Head (ft)	Energy Usage (Daily) (kWh)	Energy Use Cost (Daily) ($)
Pump Well 2	5,212.90	230S750-22DS	5,345.90	254	894.59	460.2	46.02
Pump Well 3	5,196.20	230S750-22DS	5,297.20	249	917.08	459.9	45.99
HUC Booster	5,900.00	CR32-4-2	6,208.34	173	218.67	83.0	8.30
Shung	6,330.00	CR20-2	6,397.69	117	100.49	19.2	1.92

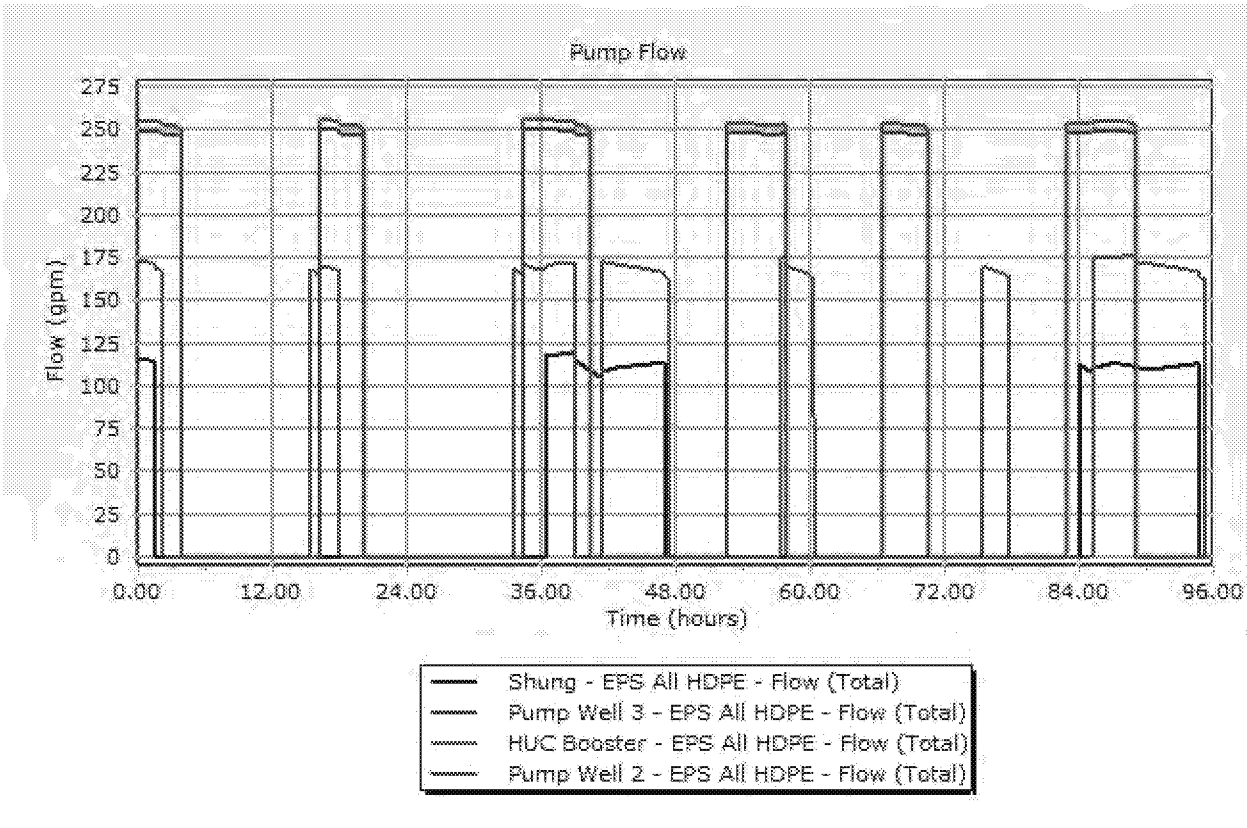
Alternative A Hopi Arsenic Mitigation Project
2017 Cycling and Energy Cost



Alternative A Hopi Arsenic Mitigation Project
2017 Cycling and Energy Cost



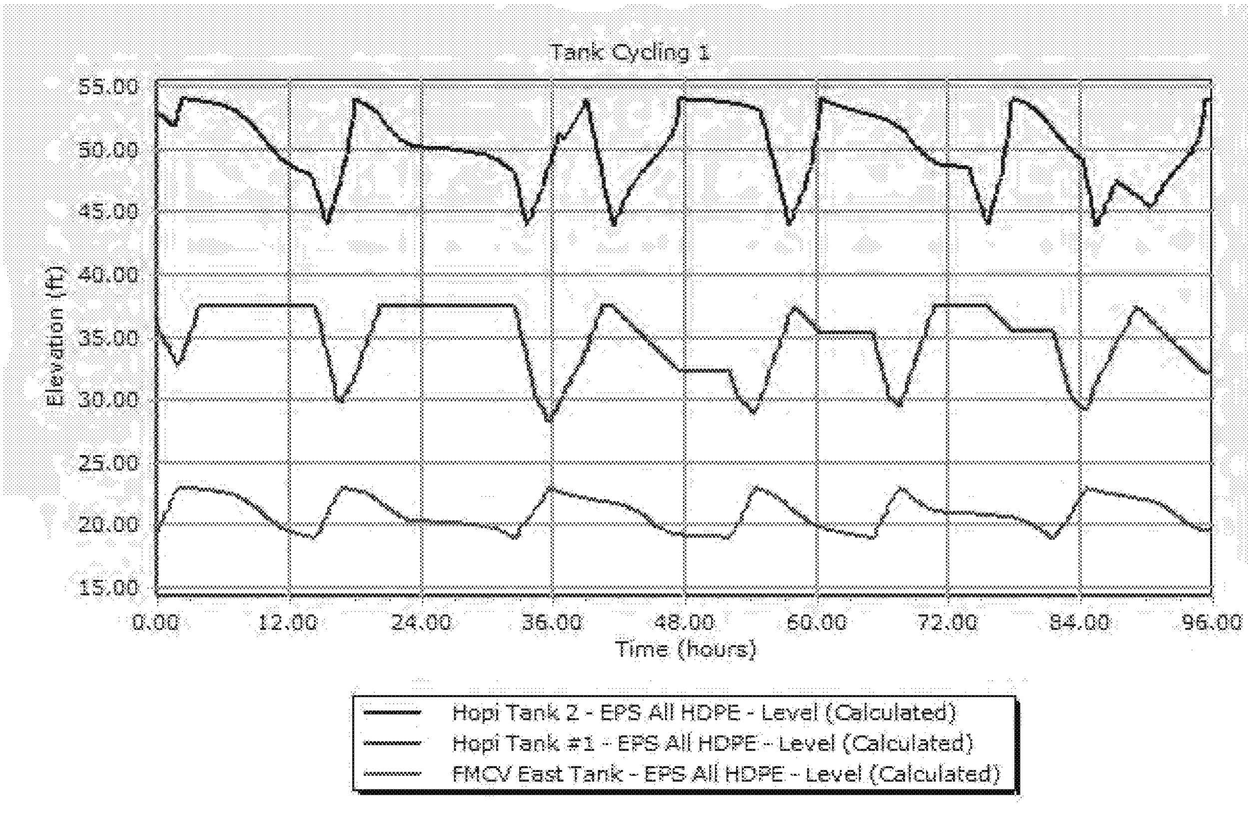
Alternative A Hopi Arsenic Mitigation Project
2037 Cycling and Energy Cost



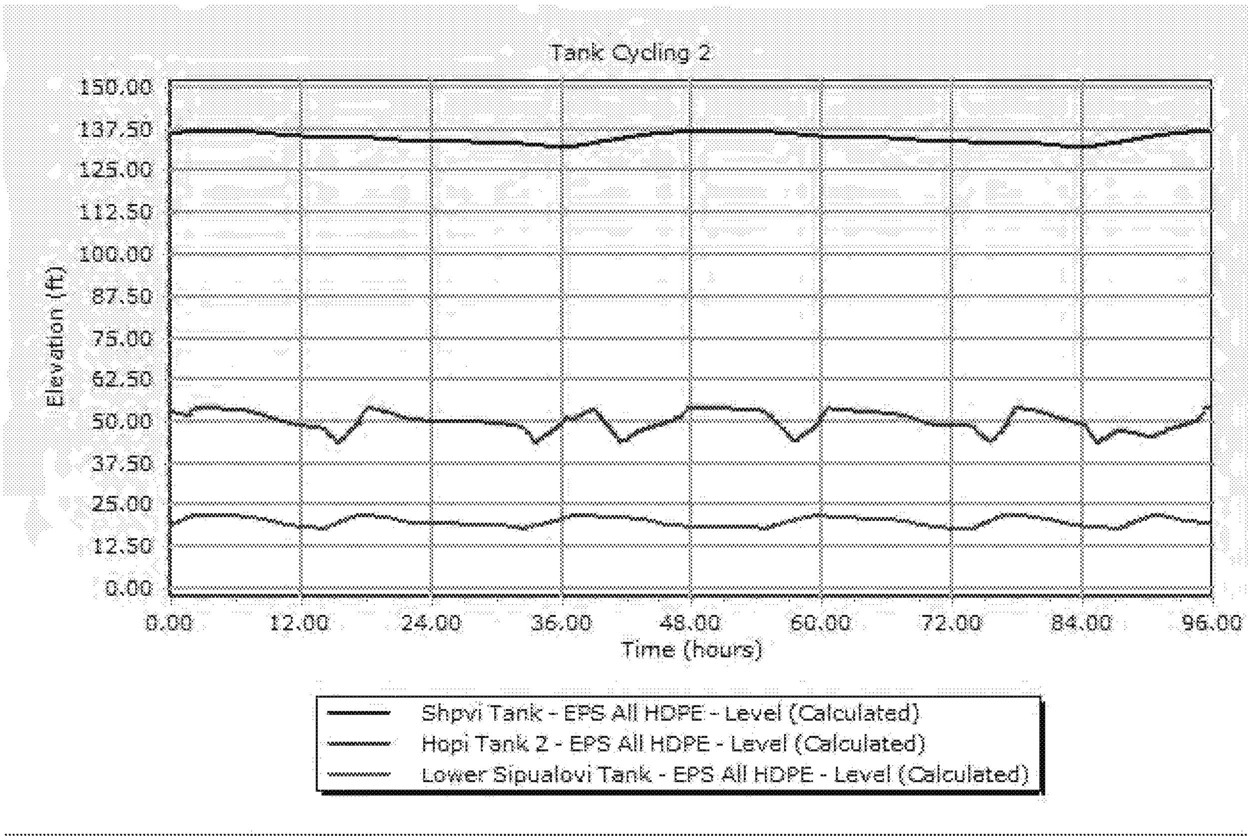
Pump Table - Time: 0.00 hours

Label	Elevation (ft)	Pump Definition	Hydraulic Grade (Suction) (ft)	Flow (Total) (gpm)	Pump Head (ft)	Energy Usage (Daily) (kWh)	Energy Use Cost (Daily) ($)
Pump Well 2	5,212.90	230S750-22DS	5,345.90	254	894.59	650.5	65.05
Pump Well 3	5,196.20	230S750-22DS	5,297.20	249	917.08	650.2	65.02
HUC Booster	5,900.00	CR32-4-2	6,208.34	173	218.66	99.6	9.96
Shung	6,330.00	CR20-2	6,397.69	117	100.49	21.3	2.13

Alternative A Hopi Arsenic Mitigation Project
2037 Cycling and Energy Cost



Alternative A Hopi Arsenic Mitigation Project
2037 Cycling and Energy Cost



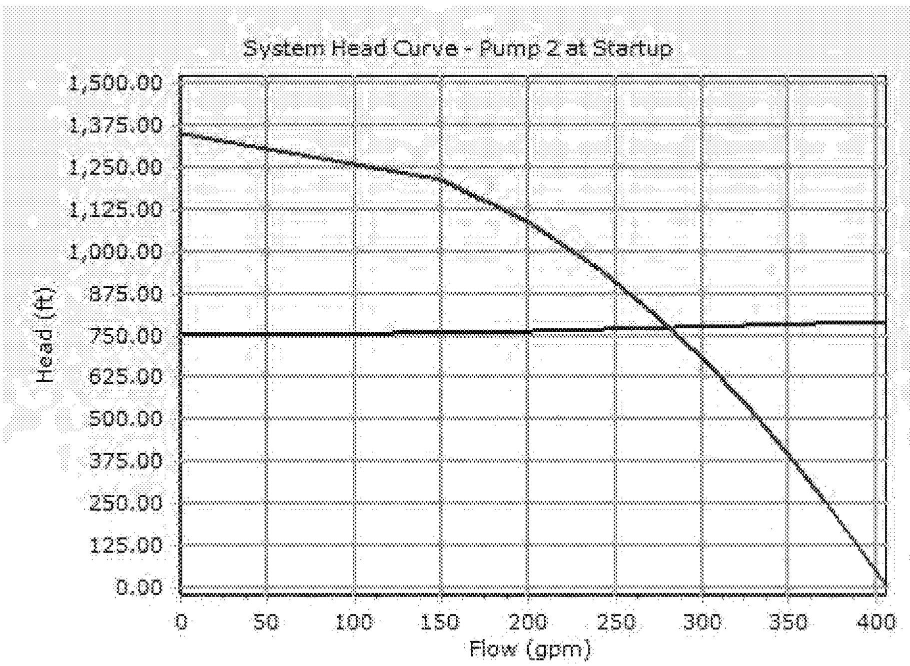
System Head Curve Detailed Report - System Head Curve - 7

Element Details

Label	System Head Curve - 7	Number of Intervals	10
Pump	PMP-Well 2	Specify vertical axis limits	False
Maximum Flow	407 gpm		

Time (hours)
0.000

System Head Curve @ 0.000 hours Flow (gpm)	System Head Curve @ 0.000 hours Head (ft)	230S750-22DS Flow (gpm)	230S750-22DS Head (ft)
0	750.33	407	0.00
41	752.04	389	135.24
81	754.35	369	270.48
122	757.20	349	405.72
163	760.55	326	540.96
204	764.39	301	676.20
244	768.70	273	811.44
285	773.48	241	946.68
326	778.71	202	1,081.92
366	784.38	150	1,217.16
407	790.50	0	1,352.40



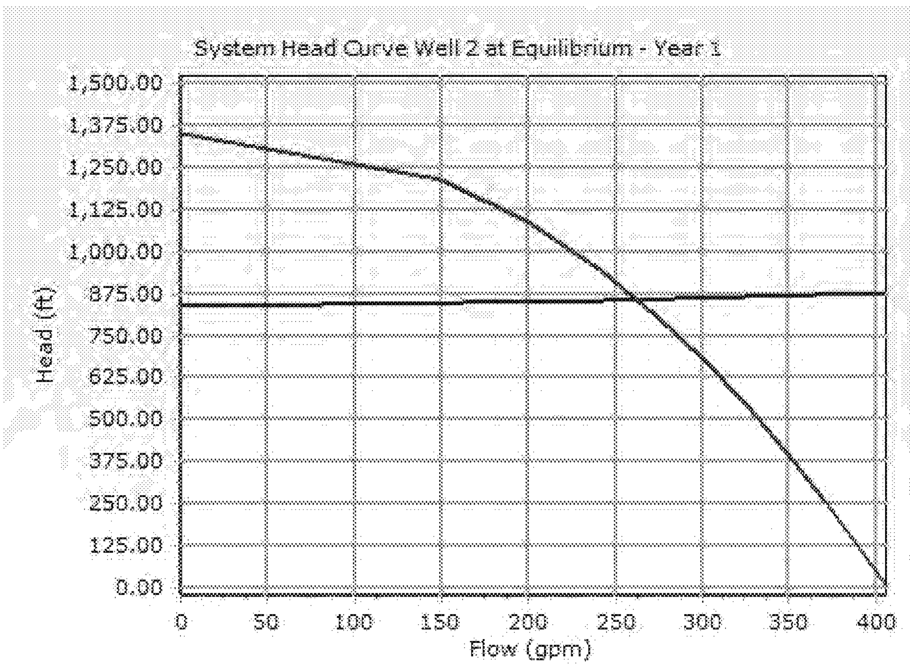
System Head Curve Detailed Report - System Head Curve - 5

Element Details

Label	System Head Curve - 5	Number of Intervals	10
Pump	PMP-Well 2	Specify vertical axis limits	False
Maximum Flow	407 gpm		

Time (hours)
0.000

System Head Curve @ 0.000 hours Flow (gpm)	System Head Curve @ 0.000 hours Head (ft)	230S750-22DS Flow (gpm)	230S750-22DS Head (ft)
0	837.58	407	0.00
41	839.19	389	135.24
81	841.40	369	270.48
122	844.14	349	405.72
163	847.39	326	540.96
204	851.13	301	676.20
244	855.34	273	811.44
285	860.02	241	946.68
326	865.15	202	1,081.92
366	870.72	150	1,217.16
407	876.74	0	1,352.40



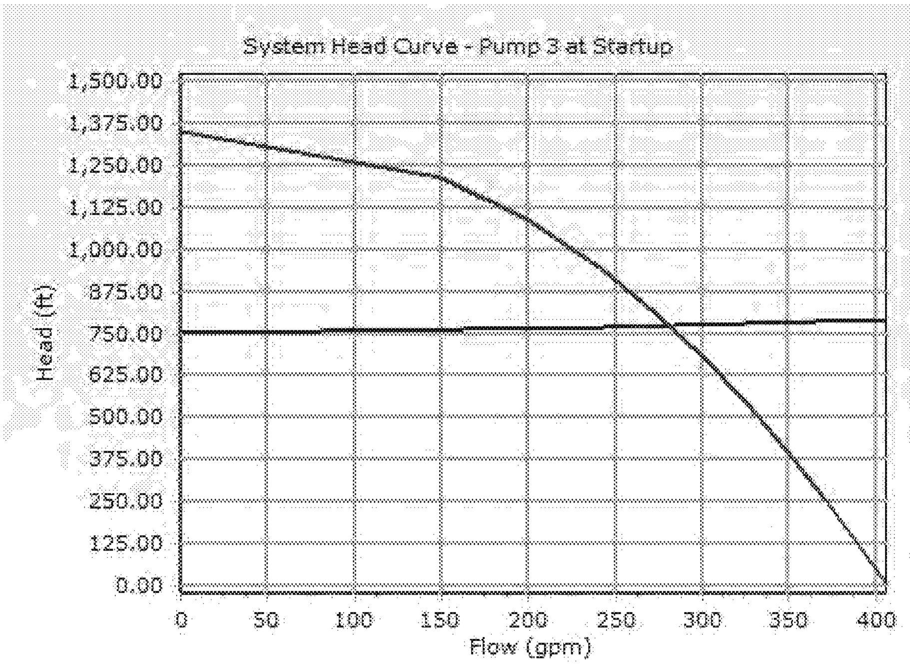
System Head Curve Detailed Report - System Head Curve - 6

Element Details

Label	System Head Curve - 6	Number of Intervals	10
Pump	PMP-Well 3	Specify vertical axis limits	False
Maximum Flow	407 gpm		

Time (hours)
0.000

System Head Curve @ 0.000 hours Flow (gpm)	System Head Curve @ 0.000 hours Head (ft)	230S750-22DS Flow (gpm)	230S750-22DS Head (ft)
0	753.34	407	0.00
41	755.02	389	135.24
81	757.26	369	270.48
122	759.99	349	405.72
163	763.19	326	540.96
204	766.84	301	676.20
244	770.92	273	811.44
285	775.43	241	946.68
326	780.36	202	1,081.92
366	785.71	150	1,217.16
407	791.46	0	1,352.40



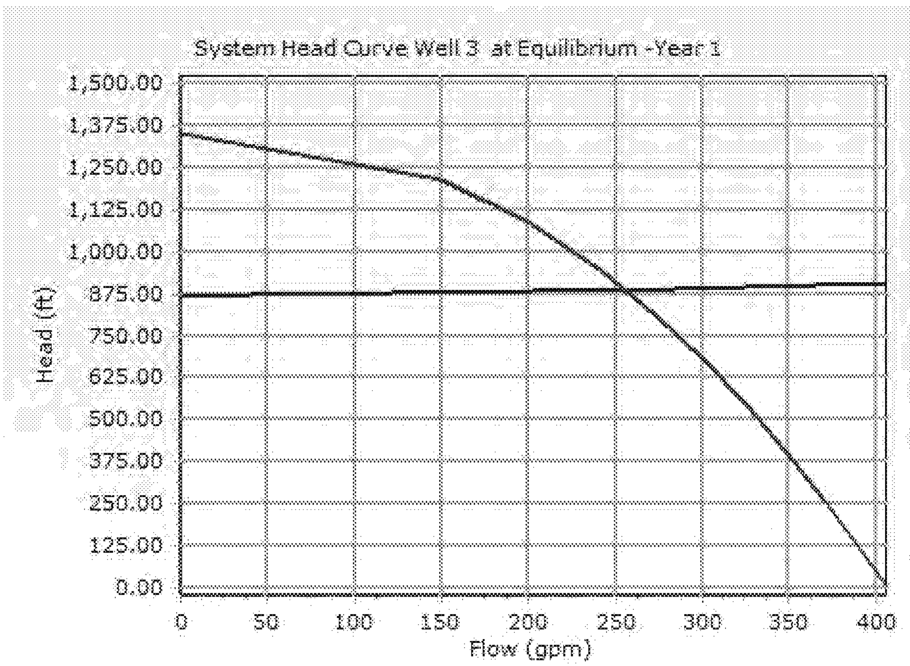
System Head Curve Detailed Report - System Head Curve - 4

Element Details

Label	System Head Curve - 4	Number of Intervals	10
Pump	PMP-Well 3	Specify vertical axis limits	False
Maximum Flow	407 gpm		

Time (hours)
0.000

System Head Curve @ 0.000 hours Flow (gpm)	System Head Curve @ 0.000 hours Head (ft)	230S750-22DS Flow (gpm)	230S750-22DS Head (ft)
0	869.51	407	0.00
41	871.11	389	135.24
81	873.28	369	270.48
122	875.93	349	405.72
163	879.05	326	540.96
204	882.62	301	676.20
244	886.63	273	811.44
285	891.07	241	946.68
326	895.93	202	1,081.92
366	901.20	150	1,217.16
407	906.88	0	1,352.40



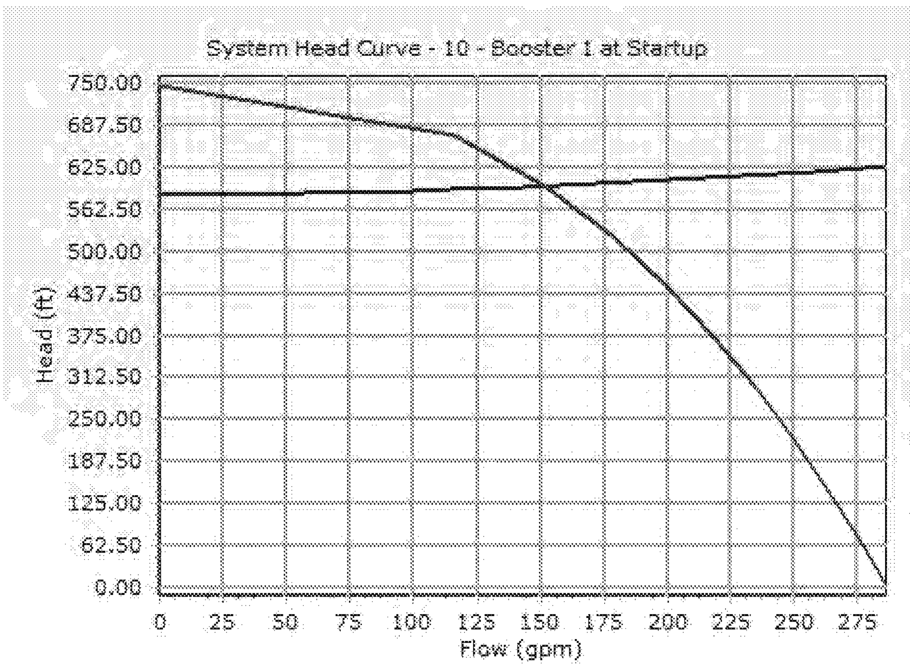
System Head Curve Detailed Report - System Head Curve - 10

Element Details

Label	System Head Curve - 10	Number of Intervals	10
Pump	Booster1	Specify vertical axis limits	False
Maximum Flow	287 gpm		

Time (hours)
0.000

System Head Curve @ 0.000 hours Flow (gpm)	System Head Curve @ 0.000 hours Head (ft)	CR32-8 Flow (gpm)	CR32-8 Head (ft)
0	584.00	287	0.00
29	584.61	275	74.66
57	586.22	263	149.31
86	588.70	249	223.97
115	592.01	235	298.63
143	596.11	219	373.29
172	600.98	200	447.94
201	606.59	179	522.60
230	612.93	153	597.26
258	619.99	116	671.91
287	627.75	0	746.57



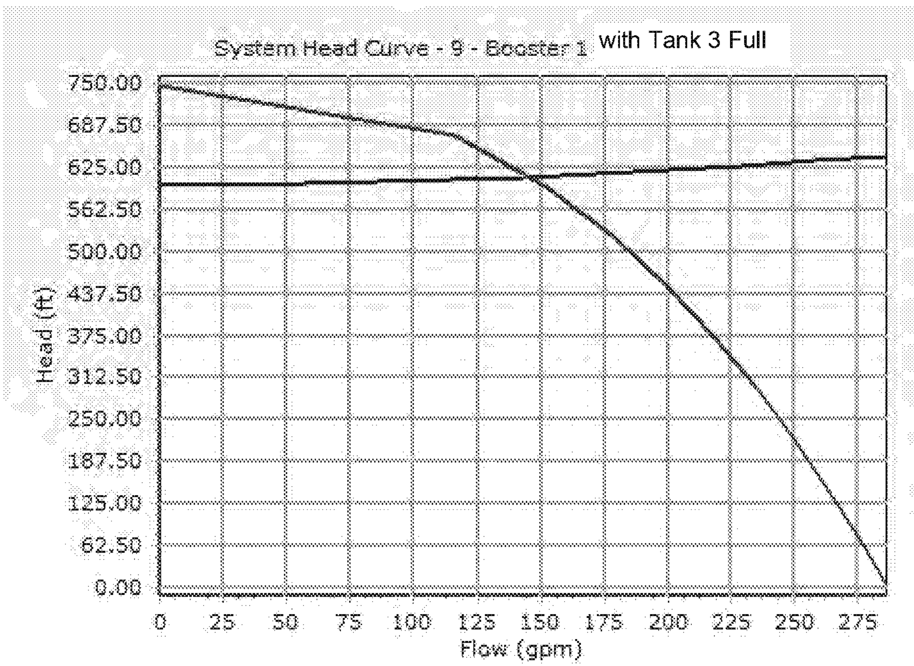
System Head Curve Detailed Report - System Head Curve - 9

Element Details

Label	System Head Curve - 9	Number of Intervals	10
Pump	Booster1	Specify vertical axis limits	False
Maximum Flow	287 gpm		

Time (hours)
0.000

System Head Curve @ 0.000 hours Flow (gpm)	System Head Curve @ 0.000 hours Head (ft)	CR32-8 Flow (gpm)	CR32-8 Head (ft)
0	599.00	287	0.00
29	599.61	275	74.66
57	601.22	263	149.31
86	603.70	249	223.97
115	607.01	235	298.63
143	611.11	219	373.29
172	615.98	200	447.94
201	621.59	179	522.60
230	627.93	153	597.26
258	634.99	116	671.91
287	642.75	0	746.57



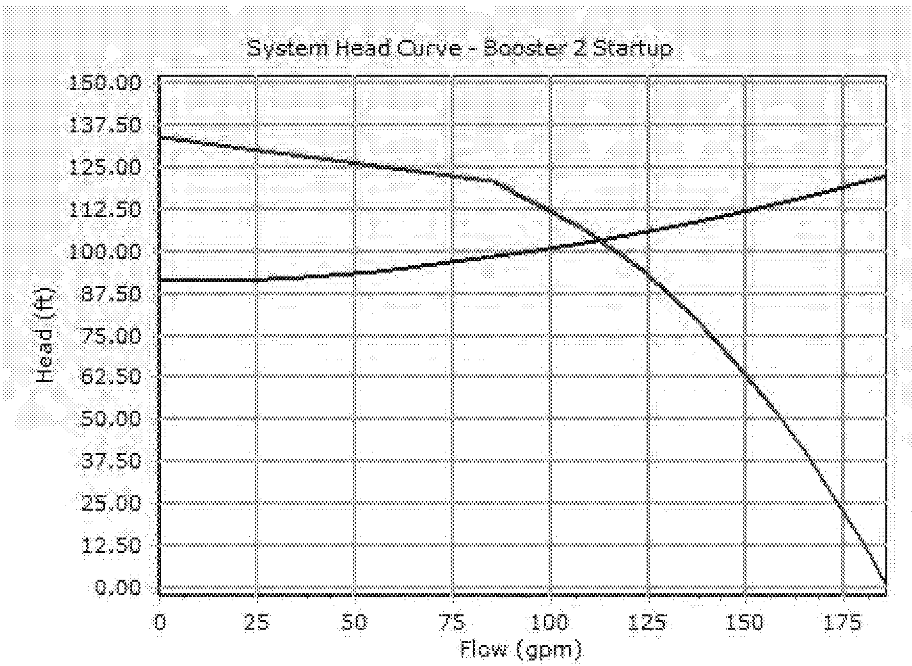
System Head Curve Detailed Report - System Head Curve - 8

Element Details

Label	System Head Curve - 8	Number of Intervals	10
Pump	Booster2	Specify vertical axis limits	False
Maximum Flow	186 gpm		

Time (hours)
0.000

System Head Curve @ 0.000 hours Flow (gpm)	System Head Curve @ 0.000 hours Head (ft)	CR20-2 Flow (gpm)	CR20-2 Head (ft)
0	91.00	186	0.00
19	91.44	180	13.43
37	92.59	173	26.86
56	94.38	165	40.28
74	96.76	157	53.71
93	99.70	147	67.14
112	103.20	136	80.57
130	107.23	124	94.00
149	111.78	108	107.43
168	116.84	85	120.85
186	122.41	0	134.28



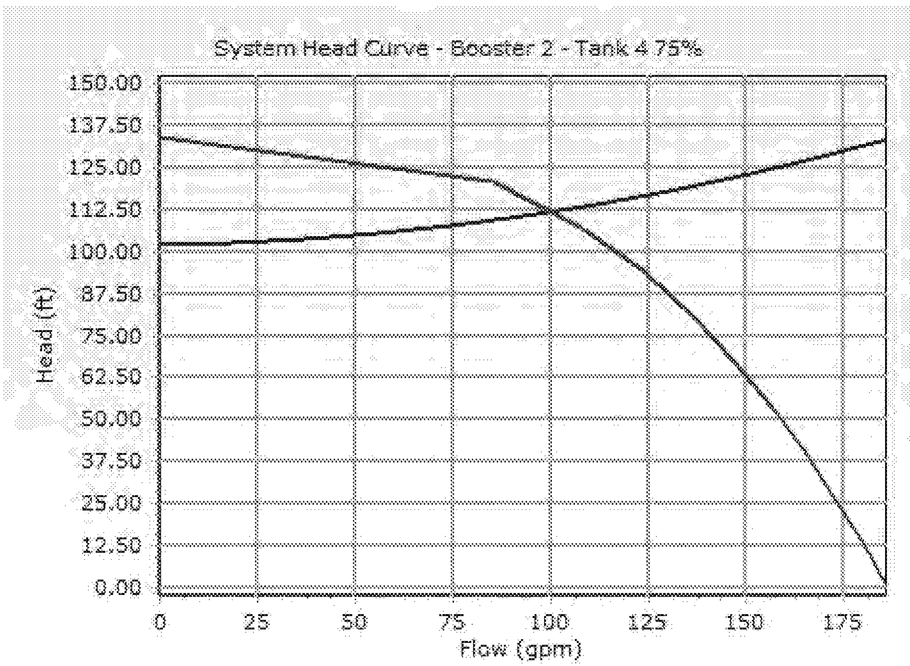
System Head Curve Detailed Report - System Head Curve - 11

Element Details

Label	System Head Curve - 11	Number of Intervals	10
Pump	Booster2	Specify vertical axis limits	False
Maximum Flow	186 gpm		

Time (hours)
0.000

System Head Curve @ 0.000 hours Flow (gpm)	System Head Curve @ 0.000 hours Head (ft)	CR20-2 Flow (gpm)	CR20-2 Head (ft)
0	102.00	186	0.00
19	102.44	180	13.43
37	103.59	173	26.86
56	105.38	165	40.28
74	107.76	157	53.71
93	110.70	147	67.14
112	114.20	136	80.57
130	118.23	124	94.00
149	122.78	108	107.43
168	127.84	85	120.85
186	133.41	0	134.28



Junction Demand Control Center

Scenario Summary

ID	405
Label	2017
Notes	
Demand	EPS Now

ID	Label	Demand (Base) (gpm)	Pattern (Demand)	Zone
160	J-19	15.50	Hydraulic Pattern - 1	Lower Sip/Mish
223	5883	1.70	Hydraulic Pattern - 1	HUC Tank 4
345	1059	29.00	Hydraulic Pattern - 1	Shungopavi
236	5944	2.50	Hydraulic Pattern - 1	HUC Tank 4
298	J-25	0.25	Hydraulic Pattern - 1	HUC Tank 4
300	J-26	0.25	Hydraulic Pattern - 1	HUC Tank 4
296	J-24	3.90	Hydraulic Pattern - 1	Route 17 Upper
149	J-18	30.00	Hydraulic Pattern - 1	FMCV West
113	J-17	75.00	Hydraulic Pattern - 1	FMCV East

FlexTable: Junction Table

Current Time: 0.00 hours

Label	Pressure (Minimum) (psi)	Pressure (Maximum) (psi)	Elevation (ft)
J-28	277	287	5,749.00
J-27	277	286	5,750.00
20251	268	277	5,770.00
20254	266	276	5,774.00
20255	264	274	5,780.00
6133	263	273	5,781.75
20253	259	269	5,790.00
6126	247	255	5,818.49
6125	228	236	5,860.96
6121	218	226	5,885.29
6120	214	221	5,894.75
6118	212	220	5,899.00
J-12	130	217	5,700.00
6106	209	217	5,905.27
6093	206	213	5,913.27
J-7	132	213	5,710.00
6069	204	211	5,917.78
J-10	121	208	5,721.28
J-9	120	207	5,725.00
6065	198	205	5,932.07
J-32	117	204	5,730.11
J-5	128	186	5,773.00
6060	175	182	5,984.45
J-11	86	174	5,800.00
6054	157	164	6,027.27
6049	141	147	6,064.32
J-14	135	144	5,885.00
J-4	110	143	5,873.00
J-16	132	142	5,892.90
J-15	130	140	5,896.20
6044	118	125	6,115.96
J-2	114	123	5,580.00
6042	114	121	6,125.90
J-33	34	121	5,924.00
6035	106	113	6,144.06
5898	96	101	6,167.55
6033	94	100	6,172.32
5902	93	99	6,174.30
5894	93	98	6,174.45
5926	92	98	6,177.03
5933	91	97	6,177.87
5912	91	97	6,178.22
5919	91	97	6,178.42
5908	91	97	6,178.22
5906	91	97	6,179.00

FlexTable: Junction Table

Current Time: 0.00 hours

Label	Pressure (Minimum) (psi)	Pressure (Maximum) (psi)	Elevation (ft)
J-35	9	96	5,980.90
5944	89	95	6,183.15
5940	89	95	6,184.22
5938	88	94	6,185.15
6031	87	94	6,187.25
5883	86	92	6,189.58
J-24	82	87	6,200.00
5838	71	76	6,322.07
5841	68	72	6,329.30
J-18	67	71	5,700.00
5861	68	71	6,327.73
5844	67	71	6,331.25
5862	69	71	6,327.63
5849	66	70	6,333.51
5870	65	67	6,335.20
5857	64	67	6,338.59
J-19	64	66	5,650.00
5881	60	63	6,348.09
1059	61	62	6,346.06
J-26	56	62	6,260.00
5872	57	59	6,353.69
5882	50	55	6,273.44
J-17	44	47	5,900.00
2625	36	41	6,304.83
J-25	34	40	6,311.00
2256	33	39	6,310.75
2698	32	38	6,313.11
5783	32	37	6,316.23
2554	30	36	6,316.82
2483	29	36	6,318.46
5784	29	35	6,321.35
2338	27	33	6,323.49
5785	27	32	6,326.53
2350	26	32	6,326.17
2785	26	32	6,327.37
J-31	24	31	6,330.00
2917	24	29	6,332.48
2836	24	29	6,333.26
2891	21	27	6,338.29
2948	22	27	6,338.45
3072	20	26	6,341.57
3127	18	23	6,347.51
5781	17	22	6,348.69
J-34	9	11	5,982.00
J-13	(N/A)	(N/A)	5,666.00

FlexTable: Junction Table

Current Time: 0.00 hours

Label	Pressure (Minimum) (psi)	Pressure (Maximum) (psi)	Elevation (ft)
J-20	(N/A)	(N/A)	5,700.00

FlexTable: Pipe Table

Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-2	28,194	67.67	0.002	11.127	HDPE	140.0	0	2.83	857
P-3	19,703	58.38	0.003	10.656	HDPE	140.0	0	3.08	857
P-5	14,530	55.89	0.004	10.100	HDPE	140.0	0	3.43	857
P-1(2)(1)(1)	20,841	45.42	0.002	7.630	HDPE	140.0	0	2.27	323
P-14	17,076	16.17	0.001	11.127	HDPE	140.0	0	1.73	523
P-93	3,388	13.03	0.004	10.100	HDPE	140.0	0	3.43	857
P-1(1)	14,039	11.33	0.001	9.357	HDPE	140.0	0	1.51	323
P-15(2)(1)	14	4.93	0.007	6.000	GI	120.0	680	3.01	265
P-13(2)(1)	13	4.82	0.007	6.000	GI	120.0	700	2.93	258
P-15(2)(2)	5,178	3.24	0.001	9.357	HDPE	140.0	0	1.24	265
P-26	1,882	2.76	0.002	6.309	HDPE	140.0	0	1.56	152
P-13(2)(2)	281	2.06	0.007	5.584	HDPE	140.0	0	3.38	258
P-9	439	1.92	0.004	10.090	HDPE	130.0	0	3.41	850
P-83	953	1.28	0.001	5.817	HDPE	140.0	0	1.43	118
P-80	3,063	1.10	0.000	7.630	HDPE	140.0	0	0.83	118
P-85	776	1.05	0.001	5.817	HDPE	140.0	0	1.43	118
P-10	347	1.01	0.003	10.656	HDPE	140.0	0	3.06	850
P-84	732	0.99	0.001	5.817	HDPE	140.0	0	1.43	118
P-44	1,369	0.98	0.001	7.305	HDPE	140.0	0	1.16	152
P-86	716	0.97	0.001	5.817	HDPE	140.0	0	1.43	118
P-82	696	0.94	0.001	5.817	HDPE	140.0	0	1.43	118
P-88(1)	656	0.88	0.001	5.817	HDPE	140.0	0	1.43	118
P-88(2)	559	0.75	0.001	5.817	HDPE	140.0	0	1.43	118
P-27	510	0.75	0.002	6.309	HDPE	140.0	0	1.56	152
P-24	500	0.73	0.002	6.309	HDPE	140.0	0	1.56	152
P-89	446	0.60	0.001	5.817	HDPE	140.0	0	1.43	118
P-25(1)	402	0.59	0.002	6.309	HDPE	140.0	0	1.56	152
P-61	908	0.52	0.001	7.630	HDPE	140.0	0	1.04	148
P-22	344	0.50	0.002	6.309	HDPE	140.0	0	1.56	152

FlexTable: Pipe Table

Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-90	359	0.48	0.001	5.817	HDPE	140.0	0	1.43	118
P-23(1)	283	0.42	0.002	6.309	HDPE	140.0	0	1.56	152
P-68	1,129	0.41	0.000	7.630	HDPE	140.0	0	0.83	118
P-77	972	0.35	0.000	7.630	HDPE	140.0	0	0.83	118
P-36	339	0.32	0.001	6.917	HDPE	140.0	0	1.30	152
P-23(2)	217	0.32	0.002	6.309	HDPE	140.0	0	1.56	152
P-38	441	0.32	0.001	7.305	HDPE	140.0	0	1.16	152
P-73	869	0.31	0.000	7.630	HDPE	140.0	0	0.83	118
P-75	779	0.28	0.000	7.630	HDPE	140.0	0	0.83	118
P-74	778	0.28	0.000	7.630	HDPE	140.0	0	0.83	118
P-35	293	0.27	0.001	6.917	HDPE	140.0	0	1.30	152
P-87	203	0.27	0.001	5.817	HDPE	140.0	0	1.43	118
P-37	292	0.27	0.001	6.917	HDPE	140.0	0	1.30	152
P-66	729	0.26	0.000	7.630	HDPE	140.0	0	0.83	118
P-76	677	0.24	0.000	7.630	HDPE	140.0	0	0.83	118
P-57	403	0.23	0.001	7.630	HDPE	140.0	0	1.04	148
P-39	308	0.22	0.001	7.305	HDPE	140.0	0	1.16	152
P-25(2)	148	0.22	0.002	6.309	HDPE	140.0	0	1.56	152
P-28	144	0.21	0.002	6.309	HDPE	140.0	0	1.56	152
P-42	291	0.21	0.001	7.305	HDPE	140.0	0	1.16	152
P-72	579	0.21	0.000	7.630	HDPE	140.0	0	0.83	118
P-79	547	0.20	0.000	7.630	HDPE	140.0	0	0.83	118
P-56	336	0.19	0.001	7.630	HDPE	140.0	0	1.05	149
P-67	537	0.19	0.000	7.630	HDPE	140.0	0	0.83	118
P-54	311	0.18	0.001	7.630	HDPE	140.0	0	1.05	149
P-47	308	0.18	0.001	7.630	HDPE	140.0	0	1.05	149
P-50	298	0.17	0.001	7.630	HDPE	140.0	0	1.05	149
P-55	295	0.17	0.001	7.630	HDPE	140.0	0	1.05	149
P-51	283	0.16	0.001	7.630	HDPE	140.0	0	1.05	149

FlexTable: Pipe Table

Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-62	283	0.16	0.001	7.630	HDPE	140.0	0	1.04	148
P-71	449	0.16	0.000	7.630	HDPE	140.0	0	0.83	118
P-48	274	0.16	0.001	7.630	HDPE	140.0	0	1.05	149
P-46	254	0.15	0.001	7.630	HDPE	140.0	0	1.05	149
P-70	396	0.14	0.000	7.630	HDPE	140.0	0	0.83	118
P-49	238	0.14	0.001	7.630	HDPE	140.0	0	1.05	149
P-69	337	0.12	0.000	7.630	HDPE	140.0	0	0.83	118
P-53	205	0.12	0.001	7.630	HDPE	140.0	0	1.05	149
P-33	125	0.12	0.001	6.917	HDPE	140.0	0	1.30	152
P-32	125	0.12	0.001	6.917	HDPE	140.0	0	1.30	152
P-45	163	0.12	0.001	7.305	HDPE	140.0	0	1.14	149
P-30	116	0.11	0.001	6.917	HDPE	140.0	0	1.30	152
P-91	79	0.11	0.001	5.817	HDPE	140.0	0	1.43	118
P-34	112	0.11	0.001	6.917	HDPE	140.0	0	1.30	152
P-43	124	0.09	0.001	7.305	HDPE	140.0	0	1.16	152
P-58	150	0.09	0.001	7.630	HDPE	140.0	0	1.04	148
P-41	98	0.07	0.001	7.305	HDPE	140.0	0	1.16	152
P-60	118	0.07	0.001	7.630	HDPE	140.0	0	1.04	148
P-59	105	0.06	0.001	7.630	HDPE	140.0	0	1.04	148
P-21	37	0.05	0.002	6.309	HDPE	140.0	0	1.56	152
P-40	74	0.05	0.001	7.305	HDPE	140.0	0	1.16	152
P-78	135	0.05	0.000	7.630	HDPE	140.0	0	0.83	118
P-52	85	0.05	0.001	7.630	HDPE	140.0	0	1.05	149
P-31	48	0.05	0.001	6.917	HDPE	140.0	0	1.30	152
P-81	121	0.04	0.000	7.630	HDPE	140.0	0	0.83	118
P-1(2)(1)(2)	11	0.02	0.002	7.630	HDPE	140.0	0	2.27	323
P-11(2)	9	0.02	0.003	11.127	Ductile Iron	130.0	0	2.80	850
P-1(2)(2)	10	0.02	0.002	7.630	HDPE	140.0	0	2.27	323

FlexTable: Pipe Table

Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-11(1)	7	0.02	0.003	11.127	Ductile Iron	130.0	0	2.80	850
P-20	20	0.01	0.001	7.305	HDPE	140.0	0	1.16	152
P-8(1)(2)	8,971	0.00	0.002	11.200	PVC	140.0	0	2.43	745
P-8(1)(1)	4,537	0.00	0.003	10.090	HDPE	140.0	0	2.99	745
P-8(2)(1)(1)(2)	2,746	0.00	0.003	10.090	HDPE	140.0	0	2.99	745
P-7(2)(2)	1,221	0.00	0.003	10.090	HDPE	140.0	0	2.99	745
P-8(2)(1)(1)(1)	152	0.00	0.007	8.486	HDPE	140.0	0	4.23	745
P-7(2)(1)	386	0.00	0.003	10.090	HDPE	140.0	0	2.99	745
P-13(1)	10	0.00	0.000	99.000	GI	140.0	1	0.01	258
P-15(1)	13	0.00	0.000	99.000	GI	140.0	1	0.01	265
P-16	55	0.00	0.001	10.000	Ductile Iron	140.0	1	2.16	529
P-17	29	0.00	0.000	11.127	Ductile Iron	130.0	0	0.00	0
P-18	41	0.00	0.000	11.127	Ductile Iron	130.0	0	0.26	78
P-63	50	0.00	0.000	7.305	HDPE	140.0	0	0.15	20
P-64	338	0.00	0.000	4.000	pvc	140.0	0	0.02	1
P-65	253	0.00	0.000	4.000	pvc	140.0	0	0.02	1
P-92	90	0.00	0.000	8.000	PVC C900	140.0	1	0.93	146
P-8(2)(2)(1)	8	0.00	0.003	10.090	HDPE	140.0	0	2.99	745
P-8(2)(1)(2)(1)	484	0.00	0.003	10.090	HDPE	140.0	0	2.99	745
P-8(2)(1)(2)(2)	9	0.00	0.003	10.090	HDPE	140.0	0	2.99	745
P-8(2)(2)(2)(1)	8	0.00	0.003	10.090	HDPE	140.0	0	2.99	745

FlexTable: Pipe Table

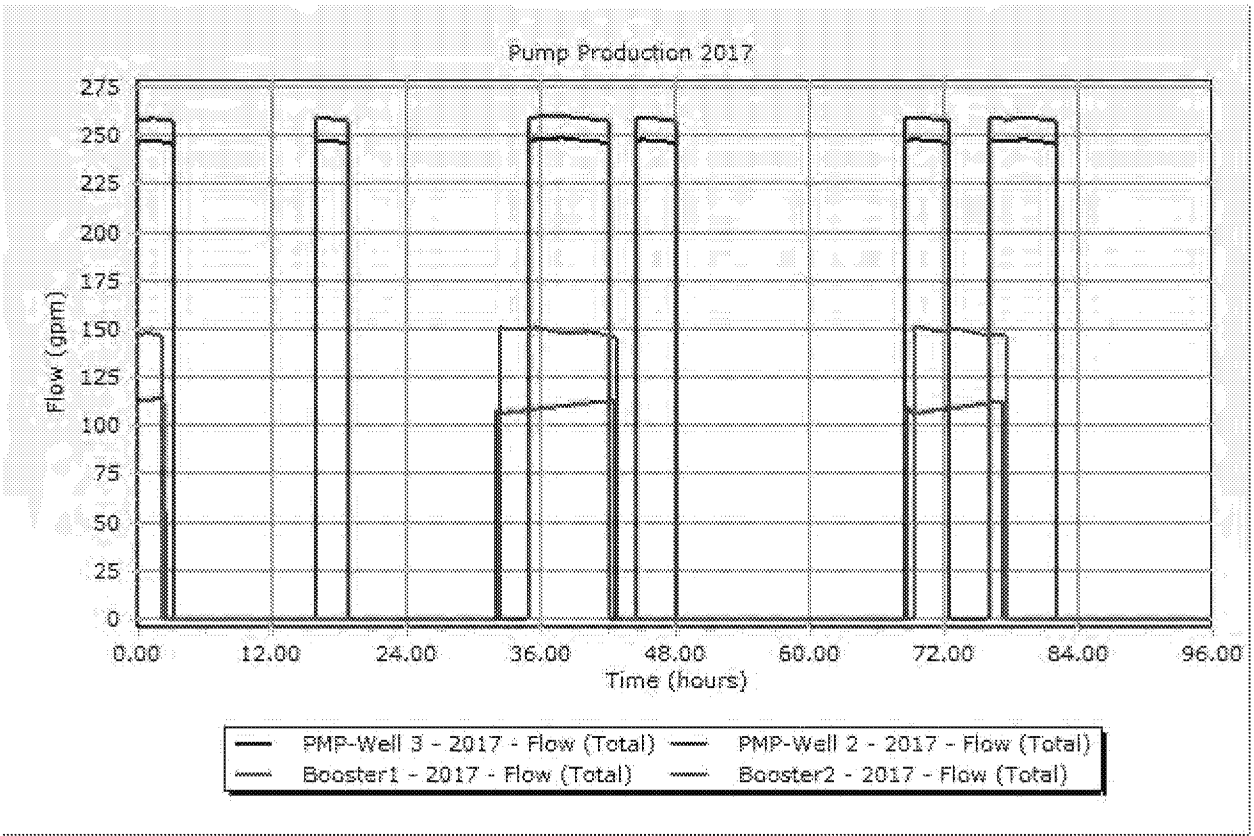
Current Time: 0.00 hours

Label	Length (Scaled) (ft)	Headloss (ft)	Headloss Gradient (Maximum) (ft/ft)	Diameter (in)	Material	Hazen-Williams C	Length (User Defined) (ft)	Velocity (Maximum) (ft/s)	Flow (Maximum) (gpm)
P-8(2)(2)(2)(2)	12	0.00	0.003	10.090	HDPE	140.0	0	2.99	745
P-12(1)	2,137	(N/A)	(N/A)	11.127	HDPE	140.0	0	(N/A)	(N/A)
P-12(2)(1)	19,278	(N/A)	(N/A)	7.300	HDPE	140.0	0	(N/A)	(N/A)
P-12(2)(2)(1)	10	(N/A)	(N/A)	11.127	Ductile Iron	130.0	0	(N/A)	(N/A)
P-12(2)(2)(2)	10	(N/A)	(N/A)	11.127	Ductile Iron	130.0	0	(N/A)	(N/A)
P-19	21	(N/A)	(N/A)	11.127	Ductile Iron	130.0	0	(N/A)	(N/A)

Alternative B Hopi Arsenic Mitigation Project

Hydraulic Model Properties	
Title	Hopi Arsenic Mitigation Project - Alternative B
Engineer	James Carter
Company	Indian Health Service
Date	6/28/2018
Notes	

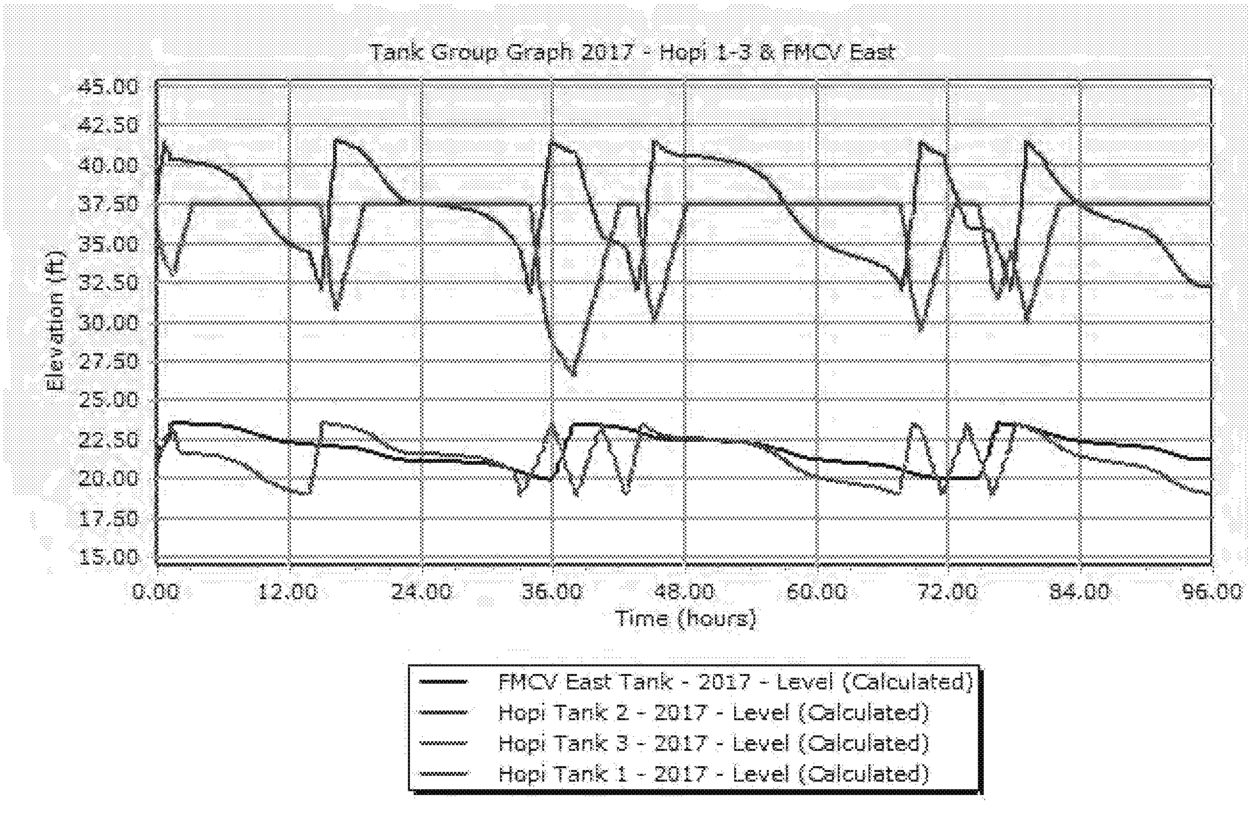
2017 Cycling and Energy Cost



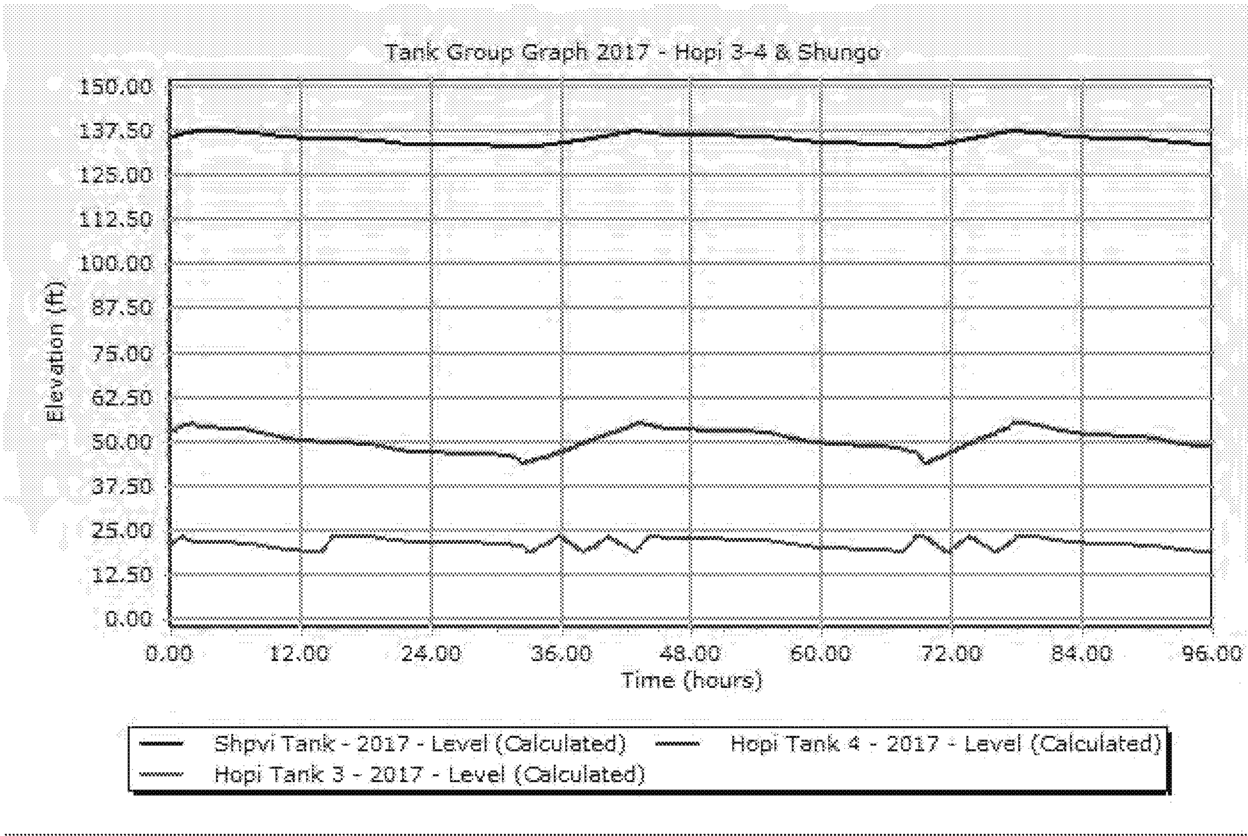
Pump Table - Time: 0.00 hours

Label	Elevation (ft)	Pump Definition	Hydraulic Grade (Suction) (ft)	Flow (Total) (gpm)	Pump Head (ft)	Energy Usage (Daily) (kWh)	Energy Use Cost (Daily) ($)
PMP-Well 3	5,196.20	230S750-22DS	5,297.20	247	925.78	421.2	42.12
PMP-Well 2	5,212.90	230S750-22DS	5,345.90	258	878.47	421.3	42.13
Booster1	5,780.00	CR32-8	5,800.99	147	609.89	127.3	12.73
Booster2	6,330.00	CR20-2	6,393.65	113	103.64	18.2	1.82

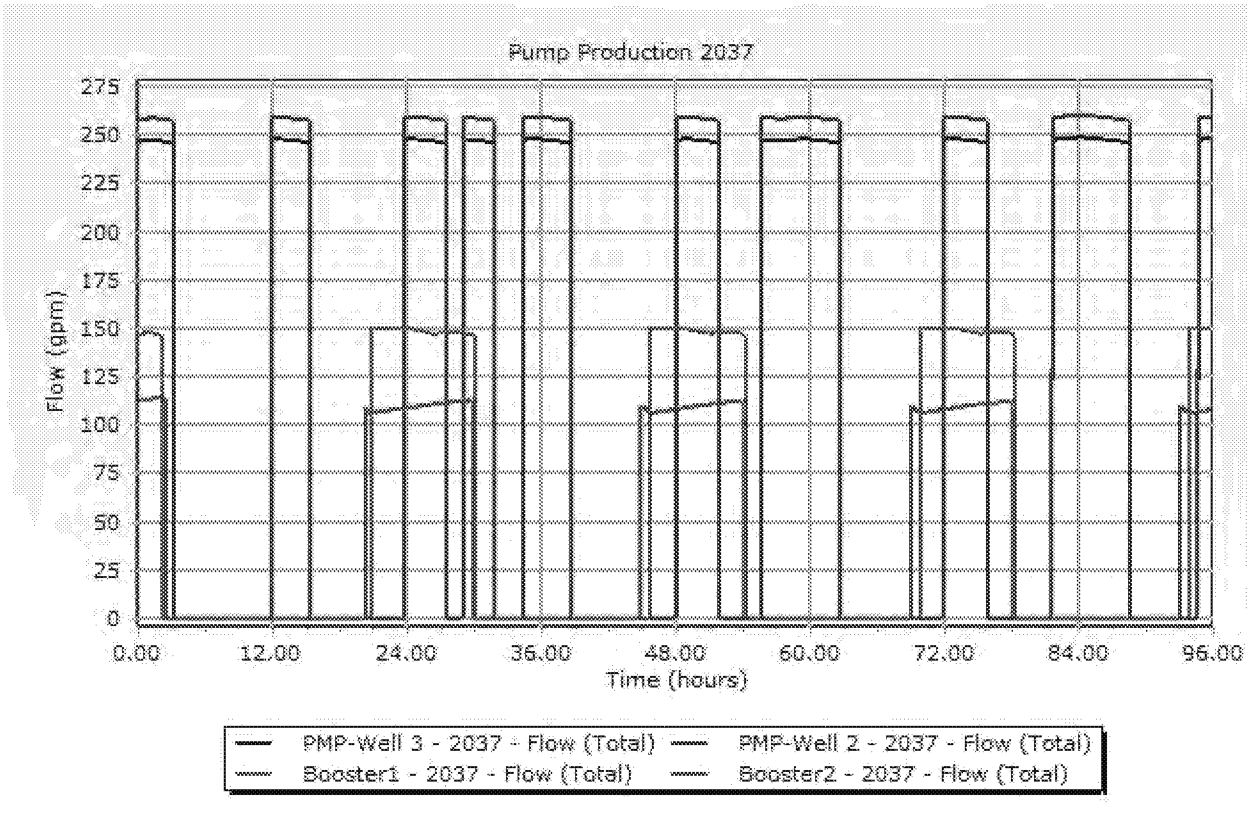
Alternative B Hopi Arsenic Mitigation Project
2017 Cycling and Energy Cost



Alternative B Hopi Arsenic Mitigation Project
2017 Cycling and Energy Cost



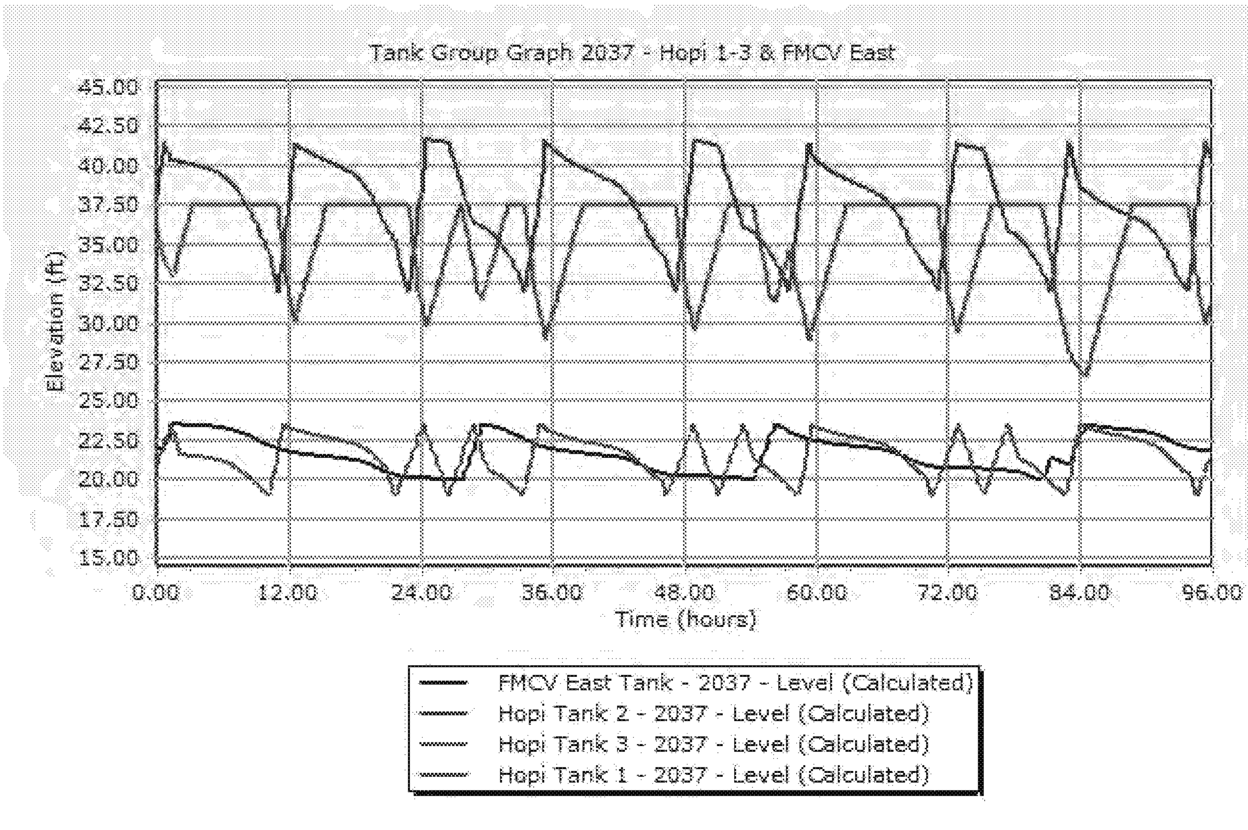
Alternative B Hopi Arsenic Mitigation Project
2037 Cycling and Energy Cost



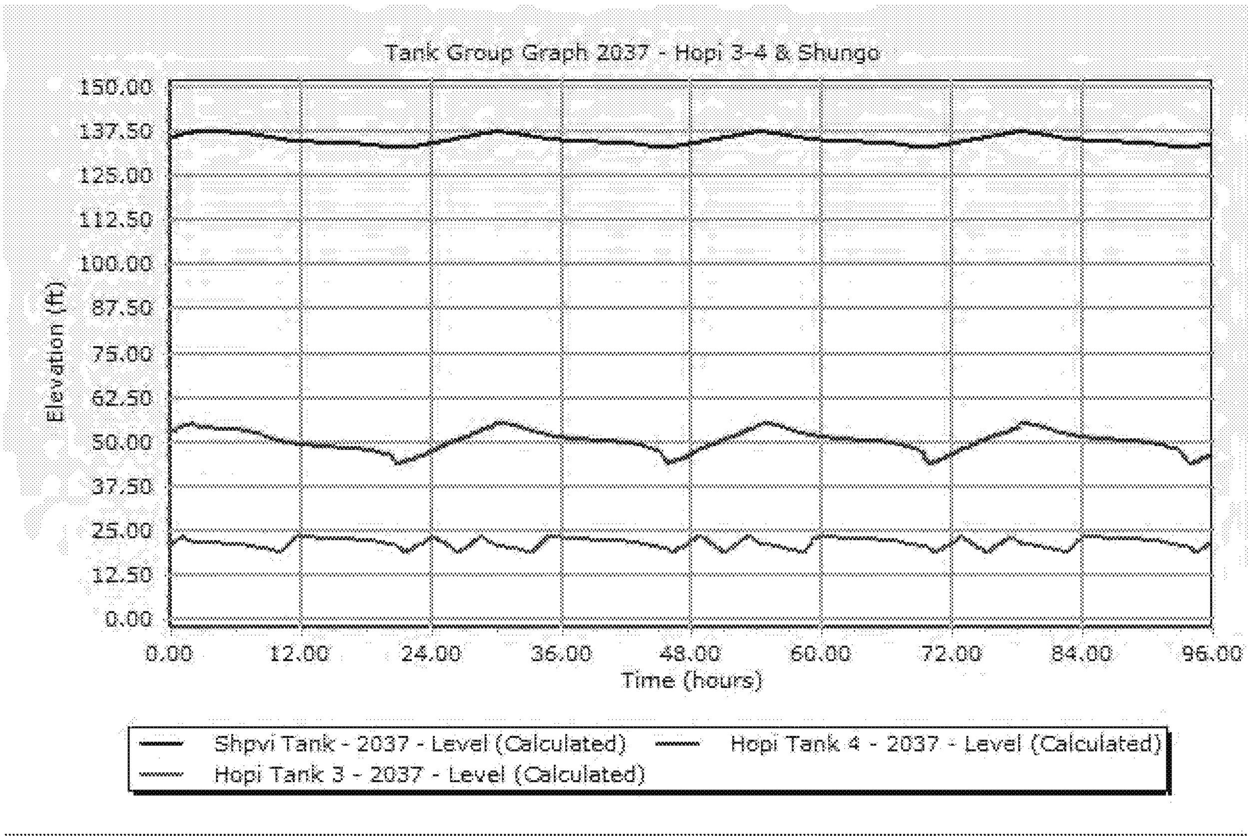
Pump Table - Time: 0.00 hours

Label	Elevation (ft)	Pump Definition	Hydraulic Grade (Suction) (ft)	Flow (Total) (gpm)	Pump Head (ft)	Energy Usage (Daily) (kWh)	Energy Use Cost (Daily) ($)
PMP-Well 3	5,196.20	230S750-22DS	5,297.20	247	925.78	655.1	65.51
PMP-Well 2	5,212.90	230S750-22DS	5,345.90	258	878.47	655.2	65.52
Booster1	5,780.00	CR32-8	5,800.99	147	609.88	190.2	19.02
Booster2	6,330.00	CR20-2	6,393.65	113	103.64	28.7	2.87

Alternative B Hopi Arsenic Mitigation Project
2037 Cycling and Energy Cost



Alternative B Hopi Arsenic Mitigation Project
2037 Cycling and Energy Cost



EVALUATION OF ALTERNATIVES

The alternatives were evaluated based on the following factors:

- Ease of Operation
- Construction Cost
- Lifecycle Cost
- Energy Cost
- R&R Cost
- NEPA Schedule
- Construction Schedule
- Visual Impacts
- Budget Risk
- Future Redundancy

Ease of Operation

Alternative A has 3 pressure reducing valves, 2 altitude valves, and a long telemetry well booster station target from where the signal is being delivered at 2nd Mesa. A repeater would likely be needed. Alternative B has 1 pressure reducing valve, and 3 altitude valves, and short line of site telemetry. In general Alternative B makes more use of gravity.

An altitude valve may be considered less risk than a pressure reducing valve. A pressure reducing valve can damage miles of expensive pipeline.

Construction Costs

See the cost estimates for the 2 alternatives. For each alternative, a soil map and a roads map shows how rock excavation quantities and the road crossing quantities were derived. Alternative A is estimated at 21.4 million including powerline costs. Alternative B is estimated at 19.2 million including powerline costs. Alternative A has a shortfall of 4.3 million and B has a shortfall of 2.1 million.

Lifecycle Costs

See the attached life cycle cost analysis. The 20 year life cycle present worth costs for alternative A is $17,271,000 and alternative B is $18,198,000.

Energy Costs

Pumping costs make up the majority of energy costs in the operation of the facilities. Alternative A has a pumping energy cost of $102.23 per day at year 2017 demand if the electric rates are estimated at $0.10/kWh. Alternative B has a pumping energy cost of $98.80 per day. That would equate to $37,313 for Alternative A in year 1 and $36,062 for Alternative B. Both alternative show a significant decrease in energy costs from that reported in the Hopi Arsenic Mitigation Project Strategic Plan, which showed $105,000 for the energy cost in year 1.

Rehabilitation and Replacement Costs

The annual rehabilitation and replacement costs for the first 20 years were calculated for each alternative. The results are shown on the HAMP R&R Present Value spreadsheets for each alternative. Alternative A has an estimated annual replacement cost of $40,349 and an annual rehabilitation cost of $40,490. Alternative B has an estimated annual replacement cost of $38,580 and an annual rehabilitation cost of $44,263. For Alternative A, R&R costs total to 80,839 and for Alternative B, R&R costs total $82,843.

NEPA Schedule

For both alternatives, Hopi Tank 1, will move a few hundred feet from where it was shown in the in the Environmental Assessment Alternative B. The route from FMCV West to East will need arch clearance, but it impact may be minimized by following along the alignments of existing utilities or the within the highway 264 corridor. For Alternative A, part of the alignment was walked within the BIA Route 4 corridor. Some of the places seemed difficult to construct within the corridor and the some of the pipeline installation may be better suited outside of the corridor, which would require more archaeology.

Construction Schedule

About 45,000 ft more 10" pipeline with Alternative A, but there are 2 more tanks with Alternative B. Alternative A has 2 times more sandstone per the USGS maps.

Visual Impacts

The tank along Route 17 was a concern for viewshed impact. Both scenarios would be best served by having the tank at that location. The site was cleared in the Environmental Assessment, but any possible impact to the viewshed should be discussed with Shungopavi. See attached google earth representation of how the new tank may look from one perspective at the Shungopavi Village. The height was adjustable in Google Earth, but the width of the tank was not easily scalable and appears to be wider than it is tall when in actuality it would be 56' high by 17' diameter. The tank could be painted to blend in to minimize the impact.

Lower Budget Risk

Alternative A has 64,000 ft of sandstone and outcrop sandstone features mostly along Route 4. Alternative B has 18,000 ft of sandstone mostly at 2nd Mesa along 264 and Route 17.

Future Redundancy

Alternative B adds a 2nd Tank near FMCV West Tank and near Lower Sipaulovi Tank. These can give the Hopi Utility System and the Village System flexibility to rely on the others tank if a tank were needed to be taken offline. The Lower Sipaulovi Tank is about 50 years old, but it was recently rehabilitated on the inside.

Weighting Decision

More weight was put on the Ease of Operation, Construction Cost, Energy Cost, NEPA Schedule, Lower Budget Risk, and Future Redundancy since the operation is critical to the longevity of the pipeline and the budget for this project is limited. The cost to the end user should be minimized by keeping the energy costs as low as possible.

Alternative Final Scoring

7/10/18

Engineering, Construction and O&M Evaluation Criteria					
	Weighting Factor	Updated Alternative A	Average x Weight	Updated Alternative B	Average x Weight
Ease of Operation	3	7	21	9	27
Construction Cost	3	3	9	7	21
Lifecycle Cost	1	6	6	7	7
Energy Cost	3	8	24	8	24
R&R Cost	2	8	16	8	16
NEPA Schedule	3	7	21	8	24
Construction Schedule	2	8	16	9	18
Visual Impacts	2	7	14	7	14
Lower Budget Risk	3	4	12	8	24
Future Redundancy	3	4	12	8	24
			151		199

Hopi Arsenic Mitigation Project
Date: 7/9/2018
Prepared By: James P. Carter

UPDATED ALTERNATIVE A COST ESTIMATE

Schedule A: Planning and Design

Item	Description	Quantity	Units	Units Cost	Total
1	Geotechnical Investigations	1	LS	$ 75,000.00	$ 75,000.00
2	Archaeological Survey and Monitoring	1	LS	$ 5,000.00	$ 5,000.00
				Pre-Construction Total:	**$ 80,000.00**

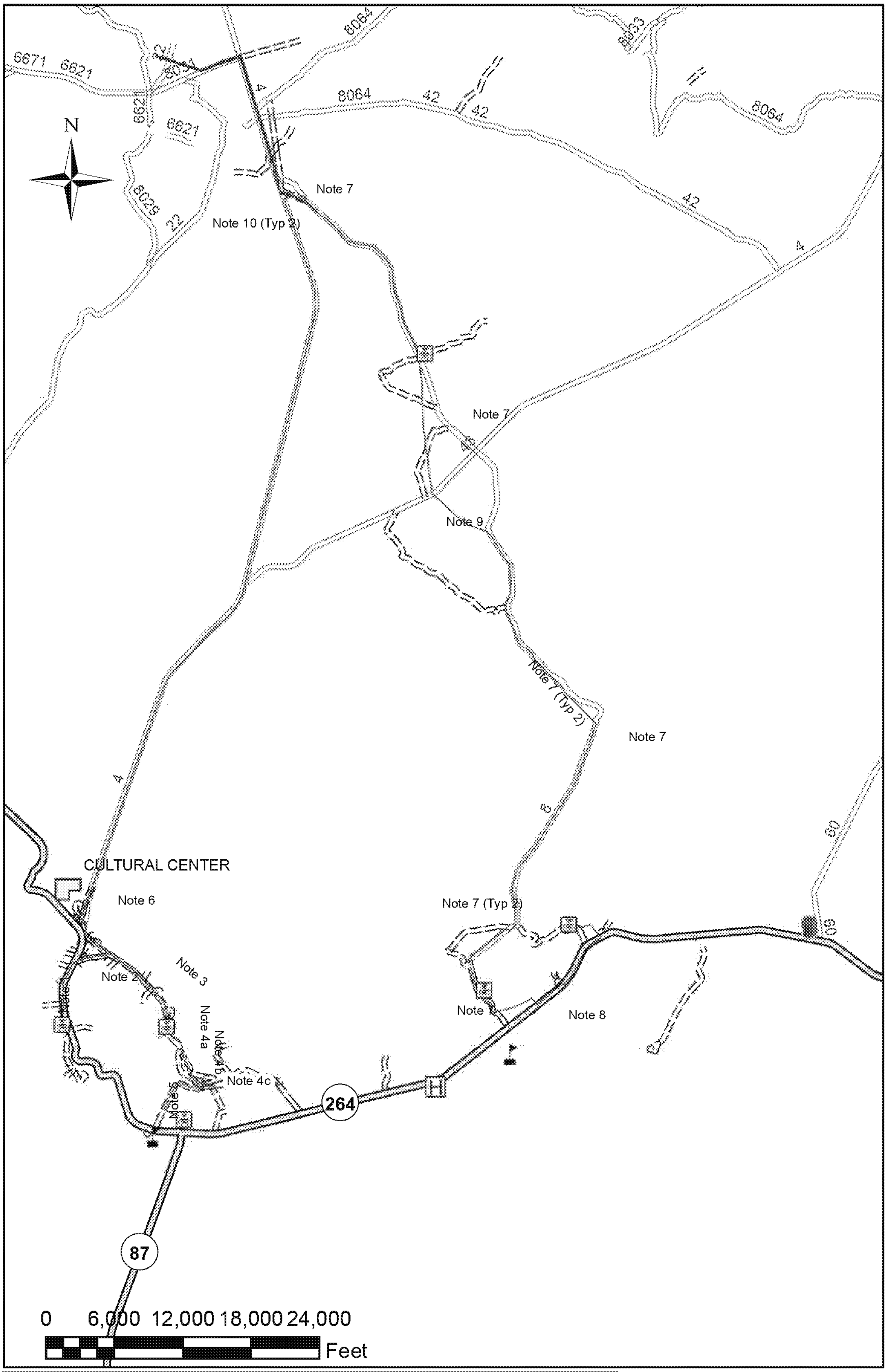
Schedule B: Construction

Item	Description	Quantity	Units	Units Cost	Total
	Power Line, Generators, and Fuel Storage				
2	150 KW Mobile Generator (Wells)	1	EA	$ 90,000.00	$ 90,000.00
3	150 KW Mobile Generator (Booster Stations)	1	EA	$ 90,000.00	$ 90,000.00
4	Power Extension (Booster 1)	1	EA	$ 15,000.00	$ 15,000.00
5	Power Extension (Booster 2)	1	EA	$ 50,000.00	$ 50,000.00
6	SWPPP	1	LS	$ 32,400.00	$ 32,400.00
	Water Mains, Gate Valves, ARVs, PRVs				
7	12" PVC C900, DR 14	9,300	LF	$ 51.62	$ 480,066.00
8	12" HDPE, SDR 9 IPS	30,812	LF	$ 60.00	$ 1,848,720.00
9	12" HDPE, SDR 11 IPS	16,300	LF	$ 53.00	$ 863,900.00
10	12" HDPE, SDR 13.5 DIPS	30,386	LF	$ 48.00	$ 1,458,528.00
11	12" HDPE, SDR 13.5 IPS	17,235	LF	$ 47.00	$ 810,045.00
12	10" HDPE, SDR 7 DIPS	7,331	LF	$ 53.00	$ 388,543.00
13	10" HDPE, SDR 9 DIPS	8,344	LF	$ 46.00	$ 383,824.00
14	10" HDPE, SDR 11 DIPS	3,300	LF	$ 42.00	$ 138,600.00
15	10" HDPE, SDR 13.5 DIPS	55,600	LF	$ 39.00	$ 2,168,400.00
16	8" HDPE, SDR 13.5 DIPS	16,700	LF	$ 32.00	$ 534,400.00
17	6" HDPE, SDR 13.5 DIPS	12,000	LF	$ 27.00	$ 324,000.00
18	4" HDPE, SDR 11 DIPS	8,440	LF	$ 27.00	$ 227,880.00
19	Rock Excavation	64,500	LF	$ 20.67	$ 1,333,215.00
20	12" Gate Valves	24	EA	$ 3,500.00	$ 84,000.00
21	10" Gate Valves	17	EA	$ 3,000.00	$ 51,000.00
22	8" Gate Valves	10	EA	$ 2,250.00	$ 22,500.00
23	6" Gate Valves	15	EA	$ 2,000.00	$ 30,000.00
24	4" Gate Valves	6	EA	$ 2,000.00	$ 12,000.00
25	Flush Valve	19	EA	$ 8,000.00	$ 152,000.00
26	Pressure Reducing Valve & Vault	3	EA	$ 20,000.00	$ 60,000.00
27	Air Relief Valves	30	EA	$ 5,000.00	$ 150,000.00
	Pumps and Motors				
28	75 hp Submersible Well Pump, Drop Pipe, Building, Ect	2	EA	$ 120,000.00	$ 240,000.00
29	15 hp Booster Station, Piping, Meter, etc.	1	EA	$ 100,000.00	$ 100,000.00
30	7.5 hp Booster Station, Piping, Meter, etc.	1	LS	$ 90,000.00	$ 90,000.00
	Tank Level Control and Connections				
31	Altitude Valve & Vault	2	EA	$ 35,000.00	$ 70,000.00
32	Master Meter	6	EA	$ 10,000.00	$ 60,000.00
33	Existing Tank Interconnection	2	EA	$ 10,000.00	$ 20,000.00
34	Telemetry	3	EA	$ 200,000.00	$ 600,000.00
	Disinfection Facilities				
35	HAMP Disinfection Facility	2	EA	$ 30,000.00	$ 60,000.00
36	Village Disinfection Facility	1	EA	$ 30,000.00	$ 30,000.00
37	Power Extensions to Village Disinfection Facilities	1	LS	$ 75,000.00	$ 75,000.00
	Wash Crossing				
38	Directional Bore - 8-inch HDPE Wepo Wash 1 location	500	LF	$ 130.00	$ 65,000.00
	Road Excavation and Repair				
39	Road Excavation and Repair - Unpaved Open Cut	2,000	LF	$ 250.00	$ 500,000.00
40	Road Excavation and Repair - Paved Open Cut	1,950	LF	$ 300.00	$ 585,000.00
41	Paved Road Crossing - Bore with Casing	1,600	LF	$ 200.00	$ 320,000.00
	Water Storage Tanks				
42	442,000 gallon Hopi Tank #1 along Route 8, 38'H x 45'D	1	LS	$ 600,000.00	$ 600,000.00
43	92,000 gallon Hopi Tank #2 at Rt 17 , 56'Hx17'D	1	LS	$ 325,000.00	$ 325,000.00
				Construction Total:	**$ 15,539,021.00**

Schedule C: O&M Support

Item	Description	Quantity	Units	Units Cost	Total
44	1-Year Start-Up Assistance	24	DAYS	$ 500.00	$ 12,000.00
45	O&M Materials, Equipment and Space	1	LS	$ 355,000.00	$ 355,000.00
46	O&M Manual Development	1	LS	$ 40,000.00	$ 40,000.00
				Post Construction Total:	**$ 407,000.00**

Planning & Design Total (Schedule A)	**$ 80,000.00**	
Construction Total (Schedule B)	**$ 15,539,021.00**	
O&M Support Total (Schedule C)	**$ 407,000.00**	
Contingencies, 10% (Schedules A, B, & C)	**$ 1,602,602.10**	
Subtotal		**$ 17,628,623.10**
TERO/Tribal Tax, 3.0%	**$ 528,858.69**	
Tribal Administrative Support Fee	**$ 354,822.46**	
Tribal Fees		**$ 883,681.16**
IHS Engineering Program Support, 10% (EPS)	**$ 400,000.00**	
IHS Project Technical Support Fee, 8% (PTS)	**$ 1,410,289.85**	
PTS &EPS		**$ 1,810,289.85**
	Total Cost	**$ 20,322,594.10**
	Rounded	**$ 20,323,000.00**
	IHS Funded	**$ 11,000,000.00**
	EPA Commitment	**$ 4,000,000.00**
	U62 EPA Funding	**$ 985,000.00**
	Shortfall	**$ 4,338,000.00**
	NTUA Powerline (By Hopi/HUC)	$ 1,100,000.00



Legend

- Tanks
- Possible_BIA_Tank_Location
- Water Pipe
- Possible BIA Waterline
- School
- Hospital

Roads

<all other values>

TYPE_GCT

- Interstate
- U.S. Highway
- State Highway
- Tribal
- County
- Roads
- BUILDING
- NTUA Powerline to Turq Trl

Notes (Subject to appropriate encroachment permits):

1. Install approximately 5,100 ft of waterline within ADOT Corridor and 1 paved road crossing (Jack & Bore)
2. Install waterline preferably outside of dirt road.
3. Install approximately 9,500 ft of waterline within the Route 17 corridor and 3 paved road crossings. (Jack & Bore). Sandstone likely.

4a. Open cut paved road crossing near Peach Lane.
4b. Install pipe preferably outside dirt road.
4c. Aproximately 1400' of open-cut paved road and 1 dirt road crossing.

5. Install pipe as far from paved route 17 road as possible.
6. Paved Road Crossing (Jack & Bore)
7. Route 8 dirt road crossing
8. Possibly 2 ADOT paved road crossings (jack and bore). May avoid by finding alternative route north of highway.
9. Route 43 open cut dirt road crossing.
10. BIA route 4 paved road crossing (jack and bore). Hard sandstone likely.

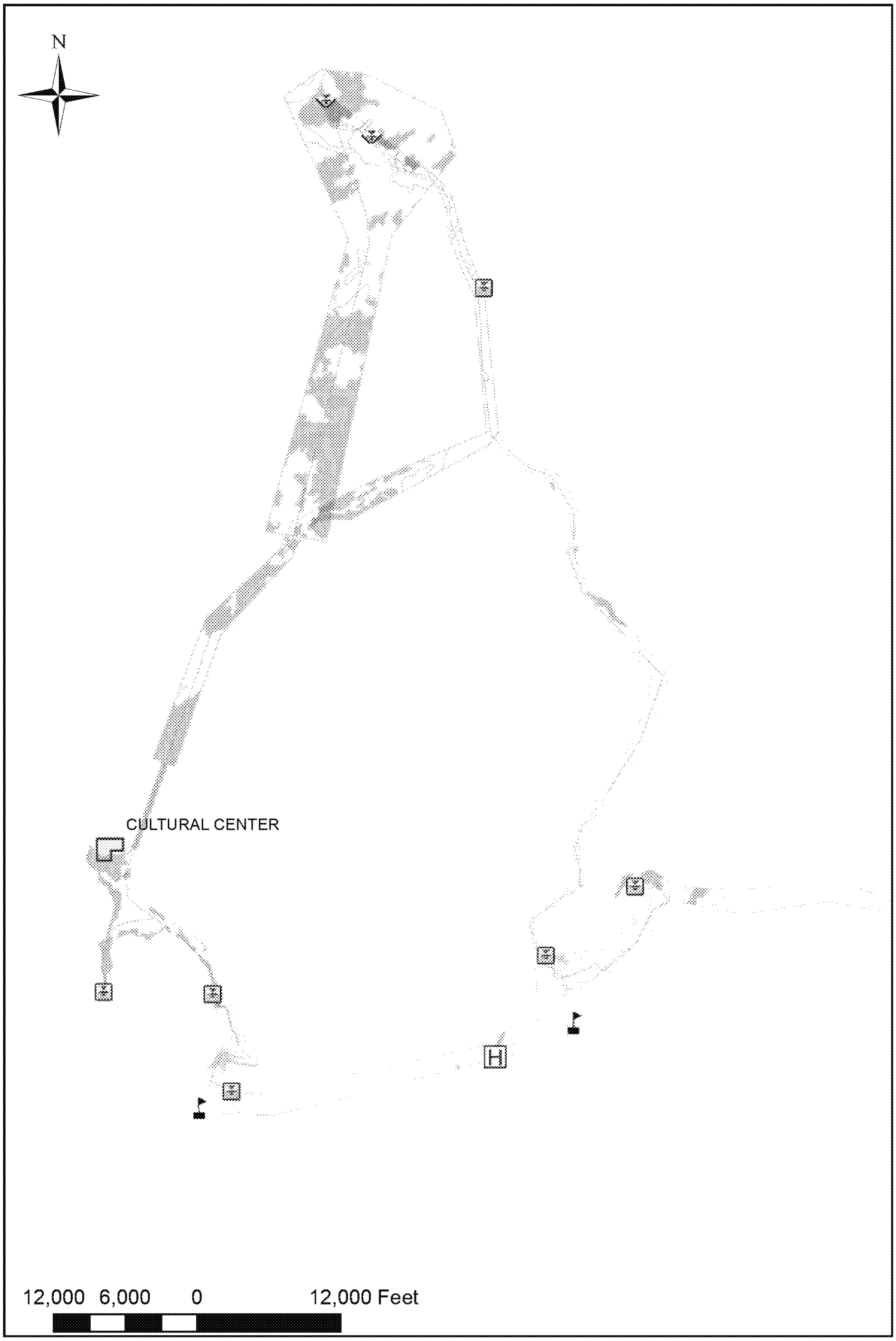
Indian Health Service
Office of Environmental Health & Engineering

Sanitation Facilities Construction
5448 S. White Mountain Blvd,
Lakeside, AZ 85929
(928) 537-0578

Phx Area IHS-Eastern Arizona District - Polacca Office
Hopi Arsenic Mitigation Project
Updated Alternative A Road Map
IHS SDS Project AZ09981-0601

Date: 6/25/18

Drawn By: JPC



Legend

- Tanks
- Wells
- Water Pipe
- School
- Hospital

soilmu_a_aoi

- <all other values>

MUSYM

- 16
- 28
- 38
- 40
- <all other values>

MUSYM

- 37
- 38
- 39
- 4
- BUILDING

Highlighted in the brighter red are the soils that are potentially sandstone per the USDA Websoil Survey Soil Unit Name.

Indian Health Service Office of Environmental Health & Engineering Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	**Phx Area IHS-Eastern Arizona District - Polacca Office Hopi Arsenic Mitigation Project Updated Alternative A Soil Map IHS SDS Project AZ09981-0601**	
	Date: 6/25/18 Drawn By: JPC	pg. 105

Hopi Arsenic Mitigation Project
Date: 7/9/2018
Prepared By: James P. Carter

UPDATED ALTERNATIVE B COST ESTIMATE

Schedule A: Planning and Design

Item	Description	Quantity	Units	Units Cost	Total
1	Geotechnical Investigations	1	LS	$ 75,000.00	$ 75,000.00
2	Archaeological Survey and Monitoring	1	LS	$ 5,000.00	$ 5,000.00
				Pre-Construction Total:	**$ 80,000.00**

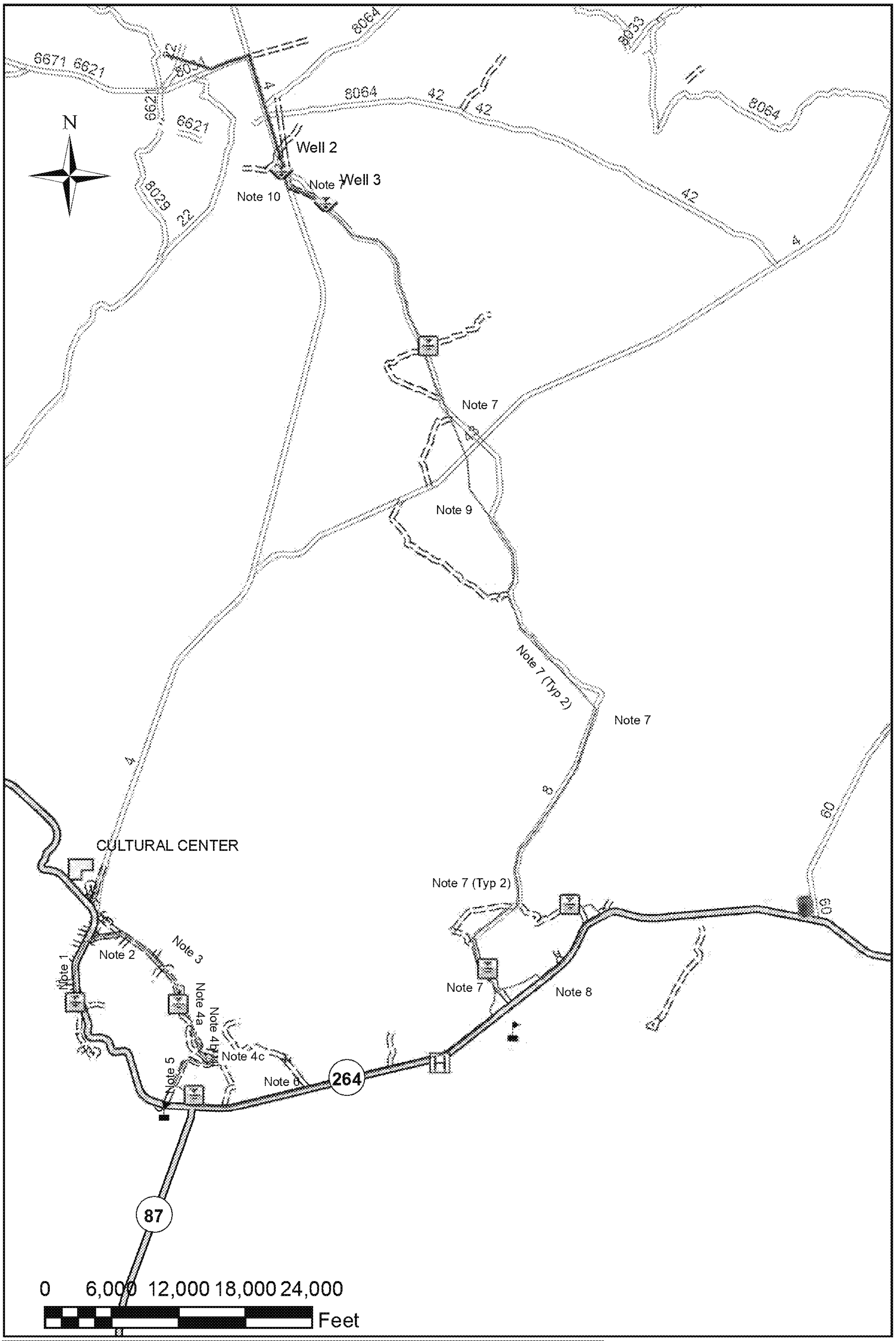
Schedule B: Construction

Item	Description	Quantity	Units	Units Cost	Total
	Power Line, Generators, and Fuel Storage				
3	SWPPP	1	LS	$ 32,400.00	$ 32,400.00
4	150 KW Mobile Generator (Wells)	1	EA	$ 90,000.00	$ 90,000.00
5	150 KW Mobile Generator (Booster Stations)	1	EA	$ 90,000.00	$ 90,000.00
	Reroute Electrical	1	EA	$ 15,000.00	$ 15,000.00
	Power Extensions	1	EA	$ 50,000.00	$ 50,000.00
	Water Mains, Gate Valves, ARVs, PRVs				
6	12" PVC C900 DR 14 (305 PSI) Many Utility Crossings	9,000	LF	$ 51.62	$ 464,593.50
7	12" HDPE, SDR 9 DIPS	27,921	LF	$ 60.00	$ 1,675,260.00
8	12" HDPE, SDR 11 DIPS	20,050	LF	$ 53.00	$ 1,062,650.00
9	12" HDPE, SDR 13.5 DIPS	45,276	LF	$ 48.00	$ 2,173,248.00
10	10" HDPE, SDR 13.5 DIPS	19,217	LF	$ 39.00	$ 749,463.00
11	8" HDPE, SDR 7 DIPS	4,465	LF	$ 44.00	$ 196,460.00
12	8" HDPE, SDR 9 DIPS	1,450	LF	$ 39.00	$ 56,550.00
13	8" HDPE, SDR 11 DIPS	3,530	LF	$ 35.00	$ 123,550.00
14	8" HDPE, SDR 13.5 DIPS	37,789	LF	$ 32.00	$ 1,209,248.00
15	6" HDPE, SDR 11 DIPS	280	LF	$ 30.00	$ 8,400.00
16	6" HDPE, SDR 13.5 DIPS	6,176	LF	$ 27.00	$ 166,752.00
17	Rock Excavation	18,000	LF	$ 20.67	$ 372,060.00
18	12" Gate Valves	24	EA	$ 3,500.00	$ 84,000.00
19	10" Gate Valves	6	EA	$ 3,000.00	$ 18,000.00
20	8" Gate Valves	21	EA	$ 2,250.00	$ 47,250.00
21	6" Gate Valves	14	EA	$ 2,000.00	$ 28,000.00
22	Flush Valve	15	EA	$ 8,000.00	$ 120,000.00
23	Pressure Reducing Valve & Vault	1	EA	$ 20,000.00	$ 20,000.00
24	Air Relief Valves	35	EA	$ 5,000.00	$ 175,000.00
	Pumps and Motors				
25	75 hp Submersible Well Pump, Drop Pipe, Building, Piping, Ect.	2	EA	$ 120,000.00	$ 240,000.00
26	40 hp Booster Station, Piping, Meter, etc.	1	EA	$ 135,000.00	$ 135,000.00
27	7.5 hp Booster Station, Piping, Meter, etc.	1	LS	$ 100,000.00	$ 100,000.00
	Tank Level Control and Connections				
28	Altitude Valve & Vault	3	EA	$ 35,000.00	$ 105,000.00
29	Master Meter	10	EA	$ 10,000.00	$ 100,000.00
30	Existing Tank Interconnection	4	EA	$ 10,000.00	$ 40,000.00
31	Telemetry	3	EA	$ 150,000.00	$ 450,000.00
	Disinfection Facilities				
32	HAMP Disinfection Facility	2	EA	$ 30,000.00	$ 60,000.00
33	Village Disinfection Facility	1	EA	$ 30,000.00	$ 30,000.00
34	Power Extensions to Village Disinfection Facilities	1	LS	$ 75,000.00	$ 75,000.00
	Wash Crossing				
35	Directional Bore - 8-inch HDPE Wepo Wash 2 locations	1,500	LF	$ 130.00	$ 195,000.00
	Road Excavation and Repair				
36	Road Excavation and Repair - Unpaved Open Cut	2,000	LF	$ 250.00	$ 500,000.00
37	Road Excavation and Repair - Paved Open Cut	1,950	LF	$ 300.00	$ 585,000.00
38	Paved Road Crossing - Bore with Casing	1,400	LF	$ 200.00	$ 280,000.00
	Water Storage Tanks				
39	442,000 gallon Hopi Tank #1 along Route 8, 38' H x 45' D	1	LS	$ 600,000.00	$ 600,000.00
40	380,000 gallon Hopi Tank #2 at FMCV, 42' H x 39' D	1	LS	$ 550,000.00	$ 550,000.00
41	110,000 gallon Hopi Tank #3 at Lower Sipaulovi 24' H x 28'D	1	LS	$ 325,000.00	$ 325,000.00
42	92,000 gallon Tank at Hopi Tank #4 at Rt 17, 56' H x 17' D	1	LS	$ 325,000.00	$ 325,000.00
				Construction Total:	**$ 13,722,884.50**

Schedule C: O&M Support

Item	Description	Quantity	Units	Units Cost	Total
43	1-Year Start-Up Assistance	24	DAYS	$ 500.00	$ 12,000.00
44	O&M Materials, Equipment and Space	1	LS	$ 355,000.00	$ 355,000.00
45	O&M Manual Development	1	LS	$ 40,000.00	$ 40,000.00
				Post Construction Total:	**$ 407,000.00**

Planning & Design Total (Schedule A)	**$ 80,000.00**	
Construction Total (Schedule B)	**$ 13,722,884.50**	
O&M Support Total (Schedule C)	**$ 407,000.00**	
Contingencies, 10% (Schedules A, B, & C)	**$ 1,420,988.45**	
Subtotal		**$ 15,630,872.95**
TERO/Tribal Tax, 3.0%	**$ 468,926.19**	
Tribal Administrative Support Fee	**$ 314,867.46**	
Tribal Fees		**$ 783,793.65**
IHS Engineering Program Support, 10% (EPS)	**$ 400,000.00**	
IHS Project Technical Support Fee, 8% (PTS)	**$ 1,250,469.84**	
PTS &EPS		**$ 1,650,469.84**
	Total Cost	**$ 18,065,136.43**
	Rounded	**$ 18,065,000.00**
	IHS Funded	**$ 11,000,000.00**
	EPA Commitment	**$ 4,000,000.00**
	U62 EPA Funding	**$ 985,000.00**
	Shortfall	**$ 2,080,000.00**
	NTUA Power Line Extension (by Tribe/HUC)	$ 1,100,000.00



Legend

- Possible_BIA_Tank_Location
- Tanks
- Wells
- Possible BIA Waterline
- Water Pipe
- School
- Hospital

Roads

<all other values>

TYPE_GCT

- Interstate
- U.S. Highway
- State Highway
- Tribal
- County
- ==== Roads
- BUILDING
- NTUA Powerline to Turq Trl

Notes (Subject to appropriate encroachment permits):

1. Install approximately 5,100 ft of waterline within ADOT Corridor and 1 paved road crossing (Jack & Bore)
2. Install waterline preferably outside of dirt road.
3. Install approximately 9,500 ft of waterline within the Route 17 corridor and 3 paved road crossings. (Jack & Bore). Sandstone likely.

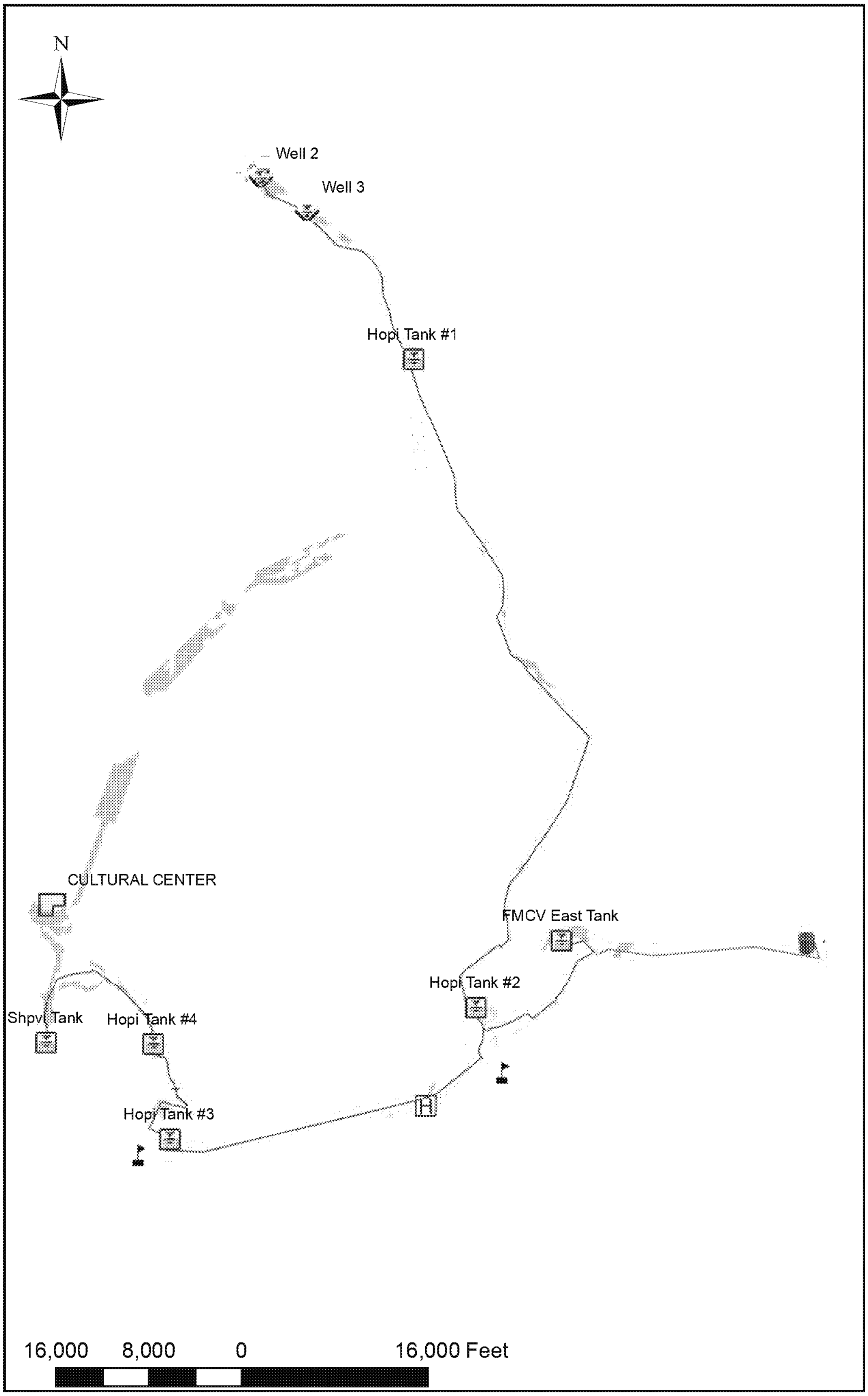
4a. Open cut paved road crossing near Peach Lane.

4b. Install pipe preferably outside dirt road.

4c. Aproximately 1400' of open-cut paved road and 1 dirt road crossing.

5. Install pipe as far from paved route 17 road as possible.
6. Install pipe within ADOT corridor. Repair paved driveways as needed.
7. Route 8 dirt road crossing
8. Possibly 2 ADOT paved road crossings (jack and bore). May avoid by finding alternative route north of highway.
9. Route 43 open cut dirt road crossing.
10. BIA route 4 paved road crossing (jack and bore). Hard sandstone likely.

INDIAN HEALTH SERVICE · PHS · 1955	Indian Health Service Office of Environmental Health & Engineering Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	**Phx Area IHS-Eastern Arizona District - Polacca Office** **Hopi Arsenic Mitigation Project** **Updated Alternative B Road Map** **IHS SDS Project AZ09981-0601** Date: 6/25/18 Drawn By: JPC pg. 107



Highlighted in the brighter red are the soils that are potentially sandstone per the USDA Websoil Survey Soil Unit Name.

INDIAN HEALTH SERVICE · PHS · 1955	Indian Health Service Office of Environmental Health & Engineering Sanitation Facilities Construction 5448 S. White Mountain Blvd, Lakeside, AZ 85929 (928) 537-0578	**Phx Area IHS-Eastern Arizona District - Polacca Office** **Hopi Arsenic Mitigation Project** **Updated Alternative B Soil Map** **IHS SDS Project AZ09981-0601** Date: 6/25/18 Drawn By: JPC pg. 108

Project	HOPI HAMP		HAMP 2018 Updated B	HAMP 2018 Updated A
Life Cycle Period	20 years			
OMB A-94 Real Interest Rate	0.20% Escalation Rate	0.00%	Note: Highlted Cells	Enter manually

http://www.whitehouse.gov/omb/circulars_a094/a94_appx-c

A. Initial Cost (Capital Cost)

	HAMP 2018 Updated B	HAMP 2018 Updated A
1. Construction	$15,630,873	$17,628,623
2. Non-Construction	$3,534,127	$3,794,377
Total Initial Costs	**$19,165,000**	**$21,423,000**

B. Operations and Maintenance (O&M)

	Reduced $54k due to savings in each village O&M	Reduced $54k due to savings in each village O&M
O&M (does not include debt or replacements-SLA)	$315,000	$315,000
Total Annual Costs	$315,000	$315,000
Present Worth Factor	19.5861	19.5861
Present Worth of RECURRENT COSTS	**$6,170,000**	**$6,170,000**

C. Replacement Reserve - Short Lived Assets (SLA)

	Years	20	20
Short Lived Assets (SLA)	Total Cost for Replacements/Repair	$1,656,860	$1,616,900
(use avg yearly SLA calculation w/o escalation)	Yearly Cost	$82,843	$80,845
	Present Worth Factor	19.5861	19.5861
	Present Worth of REPLACEMENTS	**$1,623,000**	**$1,583,000**

D. Salvage Value

NOTES	Assume most of Construction @ 60 year Life, except Pumps & Disenfection. Need to include well drilling cost	Assume most of Construction @ 60 year Life, except Pumps & Disenfection. Need to include well drilling cost
Useful Life (years)	60	60
Construction Cost - Waterlines, Tanks, Powerlines	$14,905,873	$16,928,623
Salvage Value (assume straight-line of construction cost)	$9,937,249	$11,285,749
Useful Life (years)	40	40
Construction Cost - Well Drilling/Casing	$0	$0
Salvage Value (assume straight-line of construction cost)	$0	$0
Useful Life (years)	25	25
Construction Cost - Treatment System, Disenfection, Generators & Pumps	$725,000	$700,000
Salvage Value (assume straight-line of construction cost)	$145,000	$140,000
TOTAL CONSTRUCTION COST	$15,630,873	$17,628,623
TOTAL SALVAGE VALUE	$10,082,249	$11,425,749
Present Worth Factor	0.9608	0.9608
Present Worth of SALVAGE VALUE	**$9,687,000**	**$10,978,000**

LIFE CYCLE - PRESENT WORTH SUMMARY

A. Capital Cost	$19,165,000	$21,423,000
B. Annual O&M (PRESENT WORTH)	$6,170,000	$6,170,000
C. Annual SLA (PRESENT WORTH)	$1,623,000	$1,583,000
D. Salvage Value (PRESENT WORTH)	$9,687,000	$10,978,000
G. TOTAL PRESENT WORTH COST (A+B+C-F)	**$17,271,000**	**$18,198,000**
FINAL PW COSTS	Least Expensive	More Expensive

HAMP R&R PRESENT VALUE 7/10/18
Updated Alternative A
Life Cycle, years 20
Does not include replacement in last year of life cycle
Includes rehab in last year of life cycle for assets with RUL longer than last year of life cycle
Inflation 0.02 0.02
Fund interest 0.002 0.002

	Quantity	Replace Life3 (years)	Rehab Interval (years)	Replace Cost each	Rehab Cost each	No. of Replace	2018 Annual Replace	No. of Rehabs	Sum of 20 yr Annual Rehab
Wells									
Well Pump/Motor	2	30	10 20	$ 35,000	$ 10,000	0	4105.21	2	3874.04
Casing&Screens	2	40	15	$ 500,000	$ 10,000	0	53077.54	1	1602.01
Pump Column	2	30	10 20	$ 13,000	$ 5,000	0	1524.79	2	1937.02
Valves - 8"	4	30	10 20	$ 1,500	$ 500	0	351.87	2	387.40
Well Buildings									
Structure	2	40	15	$ 40,000	$ 3,000	0	4246.20	1	530.85
VFD/PLC/Telemetry6	2	15	0	$ 40,000	$ -	1	7078.01	0	
Electrical Equip	2	30	10 20	$ 35,000	$ 5,000	0	4105.21	2	1937.02
Diesel Mobile Generator (150kw)	1	25	5 10 15 20	$ 90,000	$ 3,000	0	5765.66	4	1506.34
HVAC	1	20	5 10 15 20	$ 5,000	$ 500	0	364.48	3	251.06
Surge Tank	1	40	10 20	$ 10,000	$ 1,000	0	530.78	2	193.70
Surge Air System	1	20	10 20	$ 8,000	$ 1,000	0	583.16	1	193.70
Chlorination System	1	20	5 10 15 20	$ 5,000	$ 500	0	364.48	3	251.06
Booster Station 1									
Structure	1	40	15	$ 40,000	$ 3,000	0	2123.10	1	265.43
Pumps - Duplex Pack	1	25	10 20	$ 37,000	$ 2,000	0	2370.33	2	387.40
Yard Piping and Valves (5) 8" Valves	1	40	10 20	$ 30,000	$ 1,000	0	1592.33	2	193.70
VFD/PLC/Telemetry6	1	15	0	$ 60,000	$ -	1	5308.51	0	
Electrical Equip	1	30	10 20	$ 30,000	$ 3,000	0	1759.37	2	581.11
Diesel Mobile Generator (150KW)	1	25	5 10 15 20	$ 90,000	$ 3,000	0	5765.66	4	1506.34
Surge Tank	1	40	10 20	$ 8,000	$ 1,000	0	424.62	2	193.70
Surge Air System	1	20	10 20	$ 5,000	$ 1,000	0	364.48	1	193.70
Storage Tank									

	Quantity	Replace Life3 (years)	Rehab Interval (years)	Replace Cost each	Rehab Cost each	No. of Replace	2018 Annual Replace	No. of Rehabs	Sum of 20 yr Annual Rehab
Hopi Tank 1, 442,000 gal	1	40	20	$ 600,000	$ 30,000	0	31846.53	1	2186.87
Piping & Valves (500 ft 8-inch)	1	40	10 20	$ 35,000	$ 1,000	0	1857.71	2	193.70
Telemetry/Controls	1	15	0	$ 30,000	$ -	1	2654.25	0	
Transmission Pipelines									
12" PVC Pipe	104033	75	0	$ 53	$ -	0	301222.03	0	
10" Pipe	84,479	75	0	$ 39	$ -	0	179991.96	0	
8" Pipe	16,700	75	0	$ 35	$ -	0	31931.86	0	
4" & 6" Pipe	20440	75	0	$ 30	$ -	0	33499.77	0	
12" Isolation Valves	24	30	15	$ 4,000	$ 500	0	5630.00	1	1061.70
10" Isolation Valves	17	30	15	$ 3,000	$ 500	0	2990.94	1	752.04
8" Isolation Valves	10	30	15	$ 2,250	$ 500	0	1319.53	1	442.38
4" & 6" Isolation Valves	21	30	15	$ 2,000	$ 500	0	2463.12	1	928.99
Air Release	30	20	5 10 15 20	$ 5,000	$ 500	0	10934.34	3	7531.68
Flush Valve	19	30	15	$ 8,000	$ 500		8914.16		840.51
Pressure Reducing Valve	3	25	5 10 15 20	$ 20,000	$ 500		3843.77		753.17
Paved Roadway 1950 ft	1	20	10	$ 39,150	$ 12,000	0	2853.86	1	1449.68
Village Connections									
Flowmeter& Vault	6	25	10 20	$ 5,000	$ 1,000	0	1921.89	2	1162.21
Backflow Preventer	3	25	10 20	$ 3,000	$ 500	0	576.57	2	290.55
Chlorination Facility	1	15	5 10 15 20	$ 30,000	$ 1,000	1	2654.25	3	502.11
Altitude Valves FMCV East Tank	1	25	10 20	$ 10,000	$ 1,000	0	640.63	2	193.70
Sipaulovi/Mishongnovi Tank									
Tank, 92,000 gal	1	40	20	$ 325,000	$ 15,000	0	17250.20	1	1093.43
Yard Piping and valves (5) 8" Valves	1	40	10 20	$ 35,000	$ 1,000	0	1857.71	2	193.70
Controls	1	15	0	$ 40,000	$ -	1	3539.00	0	
Booster Station 2									
Structure	1	40	15	$ 40,000	$ 3,000	0	2123.10	1	265.43
Pumps - Duplex Pack	1	25	10 20	$ 30,000	$ 2,000	0	1921.89	2	387.40
4" Valves	8	30	15	$ 1,500	$ 500	0	703.75	1	1415.60
VFD/PLC/Telemetry6	1	15	0	$ 40,000	$ -	1	3539.00	0	

	Quantity	Replace Life3 (years)	Rehab Interval (years)	Replace Cost each	Rehab Cost each	No. of Replace	2018 Annual Replace	No. of Rehabs	Sum of 20 yr Annual Rehab
Electrical Equip	1	30	10 20	$ 30,000	$ 3,000	0	1759.37	2	581.11
Storage/Admin Building									
Structure	1	40	15	$ 75,000	$ 3,000	0	3980.82	1	265.43
Hoist	1	30	10 20	$ 10,000	$ 500	0	586.46	2	96.85
HVAC	1	20	5 10 15 20	$ 10,000	$ 1,000	0	728.96	3	502.11
Vehicles									
Service Truck	1	6 12 18	3 6 9 12 15 18	$ 30,000	$ 1,000	3	10384.00	3	942.53
ATV	1	6 12 18	3 6 9 12 15 18	$ 15,000	$ 500	3	5192.00	3	471.26
							$ 783,119		
Totals							$ 40,349		40489.70

HAMP R&R PRESENT VALUE 7/10/18
Updated Alternative B

Life Cycle, years	20	
Does not include replacement in last year of life cycle		
Includes rehab in last year of life cycle for assets with RUL longer than last year of life cycle		
Inflation	0.02	0.02
Fund interest	0.002	0.002

	Quantity	Replace Life3 (years)	Rehab Interval (years)	Replace Cost each	Rehab Cost each	2018 Annual Replace	No. of Rehabs	Sum of 20 yr Annual Rehab
Wells								
Well Pump/Motor	2	30	10 20	$ 35,000	$ 10,000	4105.21	2	3874.04
Casing&Screens	2	40	15	$ 500,000	$ 10,000	53077.54	1	1602.01
Pump Column	2	30	10 20	$ 13,000	$ 5,000	1524.79	2	1937.02
Valves - 8"	4	30	10 20	$ 1,500	$ 500	351.87	2	387.40
Well Buildings								
Structure	2	40	15	$ 40,000	$ 3,000	4246.20	1	530.85
VFD/PLC/Telemetry6	2	15	0	$ 40,000	$ -	7078.01	0	
Electrical Equip	2	30	10 20	$ 35,000	$ 5,000	4105.21	2	1937.02
Diesel Mobile Generator (150kw)	1	25	5 10 15 20	$ 90,000	$ 3,000	5765.66	4	1506.34
HVAC	1	20	5 10 15 20	$ 5,000	$ 500	364.48	3	251.06
Surge Tank	1	40	10 20	$ 10,000	$ 1,000	530.78	2	193.70
Surge Air System	1	20	10 20	$ 8,000	$ 1,000	583.16	1	193.70
Chlorination System	1	20	5 10 15 20	$ 5,000	$ 500	364.48	3	251.06
Storage Tank								
Hopi Tank 1, 442,000 gal	1	40	20	$ 600,000	$ 30,000	31846.53	1	2186.87
Piping & Valves (500 ft 8-inch)	1	40	10 20	$ 35,000	$ 1,000	1857.71	2	193.70
Telemetry/Controls	1	15	0	$ 30,000	$ -	2654.25	0	
Transmission Pipelines								
12" PVC Pipe	102247	75	0	$ 53	$ -	296050.76	0	
10" Pipe	19,217	75	0	$ 39	$ -	40943.97	0	
8" Pipe	47,234	75	0	$ 35	$ -	90315.54	0	

	Quantity	Replace Life3 (years)	Rehab Interval (years)	Replace Cost each	Rehab Cost each	2018 Annual Replace	No. of Rehabs	Sum of 20 yr Annual Rehab
4" & 6" Pipe	6456	75	0	$ 30	$ -	10580.95	0	
12" Isolation Valves	24	30	15	$ 4,000	$ 500	5630.00	1	1061.70
10" Isolation Valves	6	30	15	$ 3,000	$ 500	1055.62	1	265.43
8" Isolation Valves	21	30	15	$ 2,250	$ 500	2771.01	1	928.99
4" & 6" Isolation Valves	14	30	15	$ 2,000	$ 500	1642.08	1	619.33
Air Release	35	20	5 10 15 20	$ 5,000	$ 500	12756.73	3	8786.96
Flush Valve	15	30	15	$ 8,000	$ 500	7037.50		663.56
Paved Roadway 1950 ft	1	20	10	$ 39,150	$ 12,000	2853.86	1	1449.68
HUC Tank 2								
Hopi Tank 2, 380,000 gal	1	40	20	$ 550,000	$ 25,000	29192.65	1	1822.39
Yard Piping & Valves (8) 8-inch valve	1	40	10 20	$ 35,000	$ 1,000	1857.71	2	193.70
Altitude Valve	1	25	10 20	$ 10,000	$ 1,000	640.63	2	193.70
HUC Tank 3								
Hopi Tank 1, 110,000 gal	1	40	20	$ 325,000	$ 15,000	17250.20	1	1093.43
Yard Piping & Valves (8) 8-inch Valve)	1	40	10 20	$ 35,000	$ 1,000	1857.71	2	193.70
Altitude Valve	1	25	10 20	$ 10,000	$ 1,000	640.63	2	193.70
Village Connections								
Flowmeter& Vault	10	25	10 20	$ 5,000	$ 1,000	3203.14	2	1937.02
Backflow Preventer	3	25	10 20	$ 3,000	$ 500	576.57	2	290.55
Chlorination Facility	1	15	5 10 15 20	$ 30,000	$ 1,000	2654.25	3	502.11
Altitude Valves FMCV East Tank	1	25	10 20	$ 10,000	$ 1,000	640.63	2	193.70
Booster Station 1								
Structure	1	40	15	$ 40,000	$ 3,000	2123.10	1	265.43
Pumps - Duplex Pack	1	25	10 20	$ 50,000	$ 2,000	3203.14	2	387.40
Yard Piping and Valves (5) 8" Valves	1	40	10 20	$ 30,000	$ 1,000	1592.33	2	193.70
VFD/PLC/Telemetry6	1	15	0	$ 40,000	$ -	3539.00	0	
Electrical Equip	1	30	10 20	$ 30,000	$ 3,000	1759.37	2	581.11
Diesel Mobile Generator (150KW)	1	25	5	$ 90,000	$ 3,000	5765.66	4	1506.34

	Quantity	Replace Life3 (years)	Rehab Interval (years)	Replace Cost each	Rehab Cost each	2018 Annual Replace	No. of Rehabs	Sum of 20 yr Annual Rehab
			10					
			15					
			20					
Surge Tank	1	40	10	$ 8,000	$ 1,000	424.62	2	193.70
			20					
Surge Air System	1	20	10	$ 5,000	$ 1,000	364.48	1	193.70
			20					
Sipaulovi/Mishongnovi Tank								
Tank, 92,000 gal	1	40	20	$ 325,000	$ 15,000	17250.20	1	1093.43
Yard Piping and valves (5) 8" Valves	1	40	10	$ 35,000	$ 1,000	1857.71	2	193.70
			20					
Controls	1	15	0	$ 40,000	$ -	3539.00	0	
Booster Station 2								
Structure	1	40	15	$ 40,000	$ 3,000	2123.10	1	265.43
Pumps - Duplex Pack	1	25	10	$ 30,000	$ 2,000	1921.89	2	387.40
			20					
4" Valves	8	30	15	$ 1,500	$ 500	703.75	1	707.80
VFD/PLC/Telemetry6	1	15	0	$ 40,000	$ -	3539.00	0	
Electrical Equip	1	30	10	$ 30,000	$ 3,000	1759.37	2	581.11
			20					
Storage/Admin Building								
Structure	1	40	15	$ 75,000	$ 3,000	3980.82	1	265.43
Hoist	1	30	10	$ 10,000	$ 500	586.46	2	96.85
			20					
HVAC	1	20	5	$ 10,000	$ 1,000	728.96	3	502.11
			10					
			15					
			20					
Vehicles								
Service Truck	1	6	3	$ 30,000	$ 1,000	10384.00	3	942.53
		12	6					
		18	9					
			12					
			15					
			18					
ATV	1	6	3	$ 15,000	$ 500	5192.00	3	471.26
		12	6					
		18	9					
			12					
			15					
			18					
						$ 720,946		
Totals						$ 38,580		44262.84

Google Earth Viewshed of Tank 2 in Alternative A or Tank 4 in Alternative B from Shungopavi

Tank at 6347’ floor – 52’ tank (6400’) in Sipualovi/Mish

35-48-24.3 110-31-33.8 (52’ height) Serves all homes.